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ORIGINAL ARTICLES.

I.—On the Chert and Siliceous Schists of the Permo-Carboniferous Strata of Spitzbergen, and on the Characters of the Sponges therefrom, which have been described by Dr. E. von Dunikowski.

By George Jennings Hinde, Ph.D., F.G.S., etc.

(PLATE VIII.)

SHORTLY after the publication of my paper "On the Organic Origin of the Chert in the Carboniferous Limestone Series of Ireland," in the Geological Magazine[1] last October, my friend Prof. G. Lindström, of Stockholm, sent me a hand-specimen of cherty rock from the Permo-Carboniferous strata of Spitzbergen, which, on examination with a hand-lens, could be seen to be nearly entirely composed of spicules of sponges irregularly intermingled together, in the same manner as in the cherty beds of the Yoredale series in Yorkshire, Wales, and Ireland. This striking illustration of the organic origin of chert from a quite unexpected quarter induced me to inquire for further particulars of the nature and thickness of the rocks from which the specimen came, and Dr. A. G. Nathorst, of Stockholm, not only supplied me with the needful information which is given below, but further sent me a box of specimens of the rocks in question, which were for the most part obtained by the Swedish Expedition to Spitzbergen in 1882, under his leadership and that of the Baron de Geer. Prof. Lindström also sent for my examination most of the fossil sponges obtained by this same expedition, which have been described by Dr. v. Dunikowski;[2] and I propose in the present paper first to refer to the extent and the characters of the cherty rocks of Spitzbergen, and next to treat of the fossil sponges from them.

I may premise, however, that the specimens of cherty rock which I have examined have been in no wise selected on account of the presence in them of sponge-remains, since the origin of the rock from these organisms was not at all suspected at the time they were collected. The specimens were procured because they contain certain other fossils, such as Brachiopoda and Polyzoa, which have no special connection with the origin of the chert.

The following sketch of the stratigraphical divisions of the

[1] Dec. III. Vol. IV. pp. 435–446.

[2] Ueber Permo-Carbon-Schwämme von Spitzbergen, Kongl. Svenska Vetensk.-Akad. Handl. Bd. 21, No. 1, pp. 1–18, taf. ii. (1884).

Permo-Carboniferous series on the West and South-west shores of Spitzbergen has been kindly furnished to me by Dr. Nathorst. Some of the particulars were only obtained by the last Swedish Expedition. Dr. Nathorst makes four divisions in the series, which altogether is over 2000 m. in thickness. The lowest of these, which rests on red and green shales, regarded as Devonian, is the *Ursa sandstone*, which contains land-plants and corresponds to the European Culm or Scotch Calciferous Sandstone. In one locality, at Middle Hook in Bell Sound, Dr. Nathorst discovered in this division some intercalated marine deposits, consisting of dark schists with tracks of Annelids ("Fucoids"), Encrinital fragments, and a few siliceous Sponges.

2. *Cyathophyllum Limestone.* — This division comprises impure limestones with thin layers of chert and gypsum, also bituminous limestones with Corals, *Fusulinæ*, etc.

3. *Spirifer Limestone.*—From this division most of the fossils described from the Permo-Carboniferous series in Spitzbergen have been obtained, though it is not more than 10 mètres in thickness.

4. *Productus-chert.*—This division consists mainly of chert and siliceous rocks. Some of the beds are rich in *Producti* and other fossils, and are thus more or less calcareous; other beds are dark siliceous schists or shales, with a few Crinoidal remains and Polyzoa. It will be shown that the cherty beds are in places largely made up of the remains of siliceous sponges. Most of the fossil sponges yet known from Spitzbergen are from the lower beds of this division, which varies from 375 to 400 mètres in thickness.

A section of this division, exposed on the North Axel's Island in Bell Sound, was measured by de Geer in 1882, and the result has been communicated to me by Dr. Nathorst. It is of interest as showing the thickness of the different chert beds, and is reproduced below.

Summit—Permian Shales, Marls, and Sandstones—300m.

		mètres.	
1.	Black siliceous schist	8·9	Productus-Chert Division.
2.	Black chert (? not exposed)...	5·1	
3.	Black ,, ...	22·0	
4.	Yellow ,, ...	12·5	
5.	Black ,, ...	12·8	
6.	Yellow ,, ...	21·4	
7.	Black ,, ...	23·2	
8.	Yellow ,, ...	71·9	
9.	Dark siliceous schist...	·9	
10.	Yellow chert...	25·8	
11.	Dark gray siliceous schist	·6	
12.	Yellow siliceous schist	47·8	
13.	Black ,, ,, ...	4·2	
14.	Yellow ,, ,, ...	46·3	
15.	Black ,, ,, ...	9·5	
16.	Yellow chert	12·5	
17.	Dark ,, ...	14·0	
18.	Yellow ,, ...	4·2	
19.	Black ,, ...	58·5	
		402·1	

Owing to a slight dip in the strata, these measurements are a little in excess of the true thickness, which is estimated at 376m. Making this allowance, this division consists of 111m. of siliceous schists and 265m. or 870 feet of chert rock. The base of the division rests on the *Spirifer* limestone, whilst at its summit are the shales and marls of the Permian series, discovered for the first time by Nathorst and de Geer in 1882, the fossils in which, exclusively Permian in character, have lately been described by Prof. Lundgren.[1] The siliceous schists and cherts, therefore, known under the collective name of the Productus-chert division, constitute the summit of the Permo-Carboniferous series in Spitzbergen.

Most of the specimens of cherty rock forwarded to me by Dr. Nathorst are from the *Productus*-chert beds exposed on the eastern coast of Icefjord at Tempelberg and at Green Harbour and from Axel's Island in Bell Sound. The following are the salient characters of the principal specimens.

1. Specimens of white cherty rock at Templeberg, from near the summit of the Productus-chert and probably upon the same horizon at Angelinsberg, or Lovénsberg, in Hinlopen Strait. The rock is compact, of a greyish or milky-white tint, hard enough to scratch glass, and it gives in places slight ebullition with acid.

The Tempelberg specimens contain some grains of glauconite and quartz, but these are not present in the Hinlopen Strait example. The specimens also contain numerous shells and casts of *Productus*, and possibly also of *Spirifer*, the shells still retaining in part their normal structure of carbonate of lime. The matrix of the rock (if so it may be termed) in which these shells are imbedded, and of which their casts are composed, is a mass of closely-packed sponge spicules, chiefly linear or rod-shaped, either lying parallel to each other, or more frequently crossing one another irregularly (Pl. VIII. Fig. 8). These spicules are of chalcedonic silica; in microscopic sections by transmitted light they show an outer ring of a brownish yellow tint, whilst the central or axial portion is either of transparent silica, or of an opaque material. In some parts of the Hinlopen specimen the spicules gradually pass into a nearly pure translucent chert, in which their forms have, for the most part, disappeared, and only the solid casts of their axial canals can be distinguished.

The spicules in these rock-specimens are generally imperfect and fragmentary; the only recognizable forms are small curved cylinders with slightly inflated extremities (Pl. VIII. Fig. 9), similar to those of *Reniera clavata*, Hinde, which are very common in the cherty sponge beds of the Yoredale Series of Yorkshire and North Wales (Brit. Pal. Sponges, pt. ii. p. 143, pl. ix. figs. 5 *a*, *b*, Pal. Soc. vol. for 1887). Most of the detached spicules are apparently simple monaxial forms, and may perhaps belong to monactinellid sponges. Dr. Nathorst informs me that the bed of white chert at Tempelberg is only about three feet in thickness, but that further to the north-east it gradually

[1] Anmärkningar om Permfossil från Spetsbergen; Bihang till K. Svenska Vet. Akad. Handb. Bd. 13, Afd. iv. No. 1, pp. 1–26 (1887). *Cf.* Geol. Mag. March, 1888, p. 131.

increases in thickness. The thickness of the white chert bed in Hinlopen Strait is not known. No corresponding bed of white chert occurs in the section at Axel's Island.

2. Specimen of bluish chert from Bell Sound, probably from Axel's Island. This is a hard, brittle rock, with a splintery fracture; it gives no action with acid. It contains the mould of a large Brachiopod. The surface in places is covered with the impressions of slender elongated spicules, but in the interior of the specimen only the axial portions of the spicules remain. This specimen is precisely similar in appearance and character to the cherty rocks of the Yoredale Series in Yorkshire, and could not be distinguished from them.

3. Specimen from the *Productus*-chert at Green Harbour, Icefjord. This is a dark, siliceous rock, with *Producti*, Polyzoa, and probably small Corals. The cells of these organisms have been infilled with siliceous material, and their walls have been weathered away on the surface; the *Productus* shells are, in part, replaced by silica. No spicules can be determined on the outer surface of the rock, but they can be seen in a thin section. Amongst the monactinellid spicules there is a cruciform spicule belonging to a hexactinellid sponge (Pl. VIII. Fig. 15).

4. Specimen from the *Productus*-chert from South Axel's Island. This is a hard, dark, siliceous schist, containing fragments of the problematical fossils known as *Taonurus* or *Spirophyton*. It appears mainly to consist of very minute subangular quartz grains in a dark cement. There are scattered in the rock numerous minute cylindrical spicules, similar to those of *Reniera bacillum*, Hinde, from the Yoredale Series of Yorkshire and North Wales (Pl. VIII. Fig. 10). Frequently the spicules occur as hollow casts or partially replaced by iron rust.

5. Specimens of dark siliceous schists from the *Productus*-chert division of South Axel's Island and Middle Hook in Bell Sound. These rocks, like the preceding, are mostly made up of minute subangular grains of quartz and a varying amount of calcite. Thin sections show a few spicules in places, but they are insufficient to affect the character of the rock.

6. Nodular masses of chert intermingled with crystalline calcite from Cape Wijh. The chert in these specimens is nearly translucent, and shows but little structure. It contains traces of spicules and Foraminifera.

7. Dr. Nathorst has also forwarded to me a smooth rounded pebble of chert, from the gravels of Nordenskiöld's Berg, which are of Tertiary age, with the view of ascertaining if its minute structure corresponded with that of flints from the Chalk, which, in outward appearance, it much resembles. A microscopic section of the pebble showed that it was composed of chalcedony and crystalline silica, and that it is filled with the remains of spicules which are now for the most part only represented by the infilled casts of their axial canals; in some instances, however, the spicules consist of an opaque material. They are chiefly fragments of rod-shaped forms, but amongst them are fusiform, acerate, and also lithistid spicules, closely

resembling those of *Doryderma Dalryense*,[1] H. (Pl. VIII. Fig. 13), from the Carboniferous of Ayrshire, and minute hexactinellid spicules (Pl. VIII. Fig. 12). Both the forms of the spicules and the mineral structure of the rock point to the conclusion that the pebble has been derived from some of the cherty sponge-beds of the Permo-Carboniferous series.

The character of these chance fragments from the *Productus*-chert division of the Permo-Carboniferous series distinctly shows that the chert beds in this division are largely composed of the detached spicules of disintegrated siliceous sponges, and thus of organic origin in the same manner as the chert-beds in the Yoredale Series of Yorkshire, North Wales, and Ireland. Not only is the general character of the rock extremely similar, but in some instances the same forms of spicules are present in the Spitzbergen, as in the British rocks. The dark siliceous schists, on the other hand, intercalated between the cherts, are chiefly composed of minute grains of quartz, and thus merely of sedimentary origin, but in some of these sponge spicules are also numerously represented. It is true that the number of specimens of chert available for examination is very few, and they might be regarded as insufficient of themselves to warrant the conclusion that this great thickness of rock, which at one locality on Axel's Island reaches 870 feet, is due to the accumulation of the skeletal débris of siliceous sponges; but taking into consideration the fact that beds of similar cherty rock, which in Yorkshire[2] have an estimated thickness of 90 feet, and in North Wales of 350 feet, can be proved to be due to sponge remains, there is nothing extravagant in the supposition that this much greater thickness of rock has had a similar origin. It is reasonable to suppose, moreover, that if specimens collected indiscriminately thus show their derivation from sponge remains, still stronger evidence would be obtainable if search were specially made for it.

So far as I am aware, the Spitzbergen chert beds have never been specially studied; the principal notice of them which I have seen is by Baron A. E. Nordenskiöld,[3] who writes of them in 1876:—"In Ice and Bell Sounds, as well as in Hinloopen, the *Spirifer* Limestone and gypsum are covered by a statum of impure limestone rich in silica, or by a black flint extraordinarily rich in fossils, especially in *Producti* of large size and with large shells. Within this division the flint strata of silica are scarcely ever of the nature of sandstone, but form beds, several hundred feet thick, consisting of a nearly pure flint, and I think it highly probable that the formation of these immense flint beds stands in connexion with the eruptions whence originated the massive layers of plutonic rocks which meet us everywhere on Spitzbergen, and which in many places form the very boundary between the Mountain Limestone and the overlying strata belonging to later formations." From this it would appear that an

[1] British Fossil Sponges, pt. i. pl. v. fig. 7*b*, Pal. Soc. vol. for 1886.

[2] British Palæozoic Sponges, pt. ii. Pal. Soc. vol. for 1887, p. 100.

[3] Sketch of the Geology of Ice Sound and Bell Sound, Spitzbergen, Geol. Mag. Dec. II. Vol. III. 1876, p. 66.

organic origin of the chert, or flint as it is termed, is not even suspected, but it is supposed to have an undefined relation to igneous[1] rocks. But in the section measured by Geer on Axel's Island the chert and siliceous schists form an uninterrupted series of strata, 376 mètres in thickness, without volcanic materials, nor do such occur in the Permian strata overlying them.

The fact is not without significance that the geological horizon on which this enormous series of cherty rocks in Spitzbergen occurs corresponds approximately with that in which rocks of a similar character are so largely developed in the British Isles. The Carboniferous chert beds in Britain mainly appear in the upper portion of the *marine* Carboniferous series, between the true Mountain Limestone and the Millstone Grit. In Spitzbergen, also, they form the upper portion of a series of rocks regarded stratigraphically as the equivalents of the Carboniferous Limestone, even though they contain a certain admixture of Permian fossils. In Spitzbergen, however, the grits, sandstones, and coal-bearing beds, which succeed the Yoredale rocks in this country, are not represented, and the Permo-Carboniferous cherts are directly followed by shales, marls, and sandstones, containing an exclusively Permian Fauna.

II. On the Fossil Sponges from Spitzbergen described by Dr. E. von Dunikowski.

The cherty rocks of Spitzbergen, unlike those of Yorkshire and North Wales, have yielded entire forms of sponges, in addition to the detached spicules thickly scattered through the rock itself. These sponges were discovered by the last Swedish Expedition under Nathorst and de Geer, most of them in the dark siliceous schists of the *Productus*-chert series of Axel's Island; some were also obtained from the *Cyathophyllum* limestone of Templeberg and Gypshook, and from the *marine* beds of the Ursa sandstone at Middlehook in Bell Sound. The specimens were entrusted to Dr. E. von Dunikowski for description, who prepared microscopic sections from them, and described them as a new genus of monactinellid sponges under the name of *Pemmatites*, including within it the following species: *P. verrucosus*, *P. arcticus*, and its two varieties, *macropora* and *latituba*.

The characters assigned to the genus appeared to me so peculiar, that at my request Prof. Lindström kindly forwarded to me most of the type-specimens, and the microscopic sections from them, for examination, as well as an additional specimen of *P. arcticus*, var. *macropora*, which had not been submitted to Dr. Dunikowski, from which, and from another specimen, I have had further microscopical sections prepared. As the results of my study of these type-specimens I have arrived at conclusions as to their characters so widely

[1] A somewhat similar origin was attributed to a band of flinty or horny rock in the Carboniferous Limestone of Glencart, Dalry, Ayrshire, by my friend Mr. John Young, F.G.S., who regarded the silica as deposited chemically by heated waters from springs connected with volcanic vents in the neighbourhood (Proc. Nat. Hist. Soc. Glasgow, April 25. 1882, p. 237). Since hearing my paper on the organic origin of the Irish Carboniferous chert, Mr. Young examined sections of this flinty band under the microscope, and he has informed me that it is crowded with minute sponge-spicules, so that no doubt of its origin from these organisms can be entertained.

different from those of Dr. Dunikowski, that it will be necessary for me to state in some detail the structural features on which they are founded.

Little requires to be said of the outer form of the Sponges. They are in some cases flattened or discoid bodies, with circular, oval, or irregular outlines, in others nearly round, and, as is so frequently the case with the Palæozoic sponges, they show no stem or surface of attachment. Their exterior surfaces are usually uneven, with blunted warty eminences irregularly dispersed over them. Under favourable circumstances the surface also exhibits between the elevations a reticulation or network of siliceous translucent fibres, bounding circular or subpolygonal interspaces of a dark appearance.

The sponges are now compact throughout; in sections or fractured surfaces they exhibit a mesh of the translucent siliceous fibres, some of which have a generally radial direction from the central portion to the surface of the sponge, whilst others run transversely, and unite with the radial fibres, and thus form a connected meshwork, the spaces between which, as at the surface, are of a dark mineral (Pl. VIII. Figs. 1, 2). The sponges are now mostly of silica, but in all the specimens examined there is a slight reaction with acid.

In microscopic sections the *dark* portion of the sponge is seen to consist chiefly of minute particles and rods of an opaque material, probably of carbonaceous, though some may be of ferruginous origin, imbedded in a lighter granular (?) matrix; in this, also, are rod-shaped or acerate siliceous spicules, disposed quite irregularly both with respect to each other and to the direction of the interspaces in which they occur. Further, the spicules are by no means uniform in shape or in size in the same specimen, or in the same portion of it. There is every probability that, as suggested by Dunikowski, the dark rods mentioned above are merely replacements of siliceous spicules.

The translucent siliceous fibres of these sponges, when seen in microscopic sections, are either colourless or of a yellowish tint, their margins are uneven, they consist of fibrous radiating chalcedonic and crystalline silica, which gives brilliant tints between crossed Nicols. In this ground-mass there are frequently microscopic crystals of calcite, and here and there elongate rod-like spicules with stumpy lateral projections (Pl. VIII. Fig. 2). These spicules are frequently isolated in the fibres, their length corresponding with the direction of the fibre; occasionally several occur together closely united, evidently in their natural positions, by the apposition of their blunt projections to the surfaces of adjoining spicules (Pl. VIII. Fig. 4). They have the same general characters, and the same mode of union with each other as the spicules of lithistid sponges. Though, as a rule, only a few of these spicules now remain in the translucent fibres, their outlines are, for the most part, peculiarly distinct, and, strangely enough, though there can be no doubt that they are the spicules of siliceous sponges, and they are at present imbedded in a siliceous ground-mass, yet they are now chiefly composed of clear calcite. The fact is of importance also, that though there are plenty of acerate and smooth

rod-shaped spicules in the dark portion of the sponge, none of these forms can be seen in the translucent fibres, and, similarly, the lithistid spicules of the fibres do not occur in the dark interspaces. There is further a general uniformity in the character of these lithistid spicules, not only in the same specimen, but in those of distinct species.

Dr. v. Dunikowski attaches, in his paper, but little significance to these lithistid spicules.[1] He does indeed mention the occurrence of a few nodose irregular lithistid spicules with some of tetractinellid origin, but he thinks they have probably nothing to do with the proper skeleton of the sponges, but should be considered as merely accidentally introduced forms. I find, however, that they are very generally present in the translucent fibres of the sections[2] prepared and studied by this author.

Dr. v. Dunikowski considers that the dark portions of these sponges, which form, as already mentioned, the irregular interspaces between the translucent anastomosing fibres, are the true skeletal fibres, and the acerate spicules imbedded in them irregularly, as the monactinellid spicules proper to the skeleton. The translucent connected portions, on the other hand, which in this paper I have denominated fibres, are described by this author as the original canals of the sponge, which, after the death of the animal, have been infilled with crystalline quartz free from any admixture of those foreign substances which have given such a dark appearance to the rest of the sponge. These so-termed canals are described as main canals, and concentric or connecting canals.

My interpretation of the characters of these sponges totally differs from that of Dr. Dunikowski, for, in my opinion, the translucent anastomosing fibres—the "canals" of Dunikowski—are in reality the fibres of the sponge which were originally composed of lithistid spicules. Most of these have been dissolved, and their spaces filled with chaceldony and quartz; some remain, either singly or united in their natural positions in the fibres. The dark portions of the sponge—the "skeletal fibres" of Dunikowski—I regard as merely the irregular interspaces between the true skeletal fibres, in which the water circulation was carried on during the lifetime of the animal, and which after its death became infilled with the materials of the sea-bottom, consisting of a fine siliceous mud, with numerous spicules, chiefly of disintegrated monactinellid sponges, dispersed through it.

In support of my view, I may state that fossil lithistid sponges, in which the fibres have been replaced in a similar manner to these Spitzbergen forms, are of not unfrequent occurrence. I have before me microscopic sections of *Aulocopium* and *Astylospongia* from the Silurian strata of Gotland, in which the process has taken place; and, in one instance, the lithistid spicules are now of calcite, imbedded in a chalcedonic matrix, under the same circumstances as those of *Pemmatites*.

[1] *Loc. cit.* p. 7.

[2] They are present in seven out of ten slides of *P. arcticus*, in both of the slides of *P. verrucosus*, in two out of three slides of the var. *macropora*, and in two out of three slides of the var. *latituba*, which were sent to me by Prof. Lindström.

The dark portion of the sponge, which I regard as infilled material from the sea-bottom, is clearly of the same nature as many portions of the rock-matrix, which show in microscopic sections dark granules, rod-like bodies, and spicules of various forms interspersed in a siliceous matrix. It is quite in accordance with our experience of fossil sponges—and of recent forms as well—to find their canals and interspaces between their skeletal fibres filled with a varied assortment of spicules, often of a character quite different from those proper to the sponge itself. Further, in one of the Spitzbergen specimens the supposed canals are distinct cylindrical siliceous fibres, whilst the dark portion—the supposed skeleton—hardly shows traces of spicules, and passes uninterruptedly into the surrounding rock-matrix, and cannot be distinguished from it.

On Dunikowski's view that the siliceous fibres were originally canals, it is difficult to account for the presence in them of lithistid spicules exclusively, and it is equally as difficult to imagine that whilst foreign spicules and other materials were accidentally introduced into what are stated to be the skeletal tissues, none should have found their way into what are stated to have been the empty canals of the sponge.

But the most convincing evidence that the translucent portions in these sponges are, in reality, the skeletal fibres, and not the canals, is afforded by sections, prepared by v. Dunikowski, of a specimen from the *Cyathophyllum* limestone of Gypshook. The translucent portions in these sections are in places filled with the original spicules, running parallel with each other, and evidently in their natural position in the fibre. Unfortunately the outlines of these spicules have been rendered very indistinct by the fossilization, so that their complete forms cannot be made out definitely, and they appear to differ from the typical forms of *Pemmatites* in being furcate at one or both ends (Pl. VIII. Fig. 7). Unlike the specimens from Axel's Island, the spicules in these sections are not replaced by calcite, but consist of chalcedonic silica. The dark portions in these sections do not contain many spicules, and no doubt can be felt that they are simply the rock-matrix. The sections are named by Dunikowski, *P. arcticus*, var. *latituba*, but it is probable, judging from the form of the spicules, that the sponge is generically distinct from *Pemmatites*.

The grounds above stated appear to me to justify the view that these Spitzbergen sponges are really lithistid and not monactinellid forms. On this interpretation the diagnosis of the genus given by Dunikowski requires to be fundamentally altered; but as the term *Pemmatites* has reference to the outer form of the sponges merely, and no bearing on their inner structures, there is no reason why it should not be retained with the amended description as below:—

Order: Silicispongiæ.
Suborder: Lithistidæ.
Family: Rhizomorina.
Genus: *Pemmatites*, v. Dunikowski, emend. Hinde.

1884, Kongl. Svenska Vet.-Akad. Handl. Bd. 21, No. 1, p. 13.

Discoid, compressed or globular, sponges, apparently without stem or surface of attachment. The skeleton consists of a meshwork of subcylindrical anastomosing fibres, which are composed of rod-shaped lithistid spicules with blunted and facetted lateral processes. The open spaces between the fibres form an indefinite canal-system, with circular or polygonal apertures at the surface of the sponge.

I do not propose here to enter upon the detailed descriptions of the species and varieties given by Dunikowski, which appear to me to be substantially correct as regards the measurements and other particulars relating to the form and direction of the fibres, etc., but I may remark that in referring to them we must bear in mind that the structures described as canals are the skeletal fibres, whilst the so-termed fibres are only the interspaces between the real fibres, now infilled with matrix. Examined from the new point of view, the sponges described as varieties *macropora* and *latituba* (*loc. cit.* pp. 15, 16) appear to be sufficiently distinct from *P. arcticus* to be considered as separate species.

The lithistid spicules in these sponges, as shown by the accompanying figures (Pl. VIII. Figs. 3–6), vary somewhat in size and form; for the most part they consist of a straight or slightly curved rod-like axis, truncated or obtusely pointed at the ends, with short lateral projections terminating in minute facets.[1] They vary from ·4 to ·6 mm. in length, and about ·06 mm. in thickness.

I have not been able to detect a dermal layer (Deckschicht) as distinct from the fibres, in any of the sponges; the structure so named and figured by Dunikowski appears to me to be merely a thin layer of matrix incrusting the surface of the sponge.

Whilst thus differing from Dr. Dunikowski as to the interpretation of the structure of these sponges, I wish to bear testimony to the very careful manner in which he has investigated and described their characters. The specimens are in a very unfavourable state of preservation, and owing to the very complicated changes which take place in the fossilization, it is, without special experience, easy to make a mistake in determining the original characters of these organisms from the older rocks.

Summary.

Specimens of chert-rock from the *Productus*-chert division of the Permo-Carboniferous series of Spitzbergen are shown to consist largely of detached siliceous sponge spicules, thus indicating the probable derivation of this rock from the skeletal remains of these organisms. The chert is of the same character as that of the Yoredale beds of the British Isles, and it occurs on the same relative geological horizon. The *Productus*-chert division has a thickness on Axel's Island of 376 m., of which 265 m. are chert, and 111 m. dark siliceous schists, likewise containing sponge remains, but less abundantly than the chert. The chert had previously been regarded as connected in some way with the igneous rocks of the island.

[1] As already mentioned, the spicules in *Pemmatites latituba* differ in form, and they are more slender than in the other species described.

The Sponges obtained from these rocks, which had been described as Monactinellid forms by v. Dunikowski, are shown to be really Lithistid sponges, this author having mistaken the original fibres for canals, and the infilling matrix, in which detached spicules occur, for the fibrous skeleton of the sponge.

EXPLANATION OF PLATE VIII.

FIG. 1. Part of a vertical section of *Pemmatites macropora*, Dunik., showing the disposition of the translucent skeletal fibres and the dark matrix. Enlarged four diameters. From the *Productus*-chert beds of the Permo-Carboniferous series, Bell Sound, Spitzbergen.

„ 2. Part of a section from the same specimen, enlarged twenty diameters, showing lithistid spicules in the translucent fibres, as well as crystals of calcite.

„ 3. Detached spicules from the same section, enlarged sixty diameters.

„ 4. Spicules from the same, showing their mode of union with each other. Enlarged sixty diameters.

„ 5. Two detached spicules occurring in the translucent fibres of *Pemmatites arcticus*. Enlarged sixty diameters. Drawn from a section prepared by v. Dunikowski.

„ 6. Two spicules from the translucent fibres of *P. verrucosus*, Dunik., similarly enlarged. Also from one of Dunikowski's sections.

„ 7. Part of a section of *P. latituba*, Dunik., from the *Cyathophyllum*-limestone at Gypshook, Bell Sound, showing spicules (now partially obliterated) in the translucent fibres. Enlarged sixty diameters. Drawn from a section prepared by v. Dunikowski.

„ 8. A section of the White Chert from Templeberg, Spitzbergen, showing its structure of sponge-spicules irregularly intermingled together. Enlarged forty diameters.

„ 9. Two detached cylindrical spicules of *Reniera clavata*, Hinde, from the White Chert of Templeberg. Enlarged sixty diameters.

„ 10. Detached cylindrical spicules of *Reniera bacillum*, Hinde, from a section of the *Productus*-chert at South Axel's Island. Enlarged sixty diameters.

„ 11. A fusiform acerate spicule from a section of a chert pebble (probably from the Permo-Carboniferous), from the Tertiary gravels of Nordenskiold's Berg. Enlarged sixty diameters.

„ 12. Flesh spicule of hexactinellid sponge from the same pebble. Enlarged 175 diameters.

„ 13. Lithistid spicule of *Doryderma Dalryense* (?), Hinde, from the same pebble.

„ 14. 15. Modified hexactinellid spicules. Enlarged sixty diameters. From Axel's Island and Green Harbour, *Productus*-chert series.

II.—New Palæoniscidæ from the English Coal-Measures. No. II.

By Dr. R. H. Traquair, F.R.S., F.G.S.

(For No. I. see Geol. Mag. Dec. III. Vol. III. 1886, p. 440.)

Elonichthys Binneyi, sp. nov., Traquair.

Of this I have seen only two specimens. One of them, slightly longer than the other, measures $3\frac{1}{2}$ inches in length up to the commencement of the caudal fin, which is deficient in both; the greatest depth of the body $\frac{1}{2}\frac{1}{2}$ inch, the length of the head nearly the same. The dorsal fin is opposite the interval between the ventral and the anal; both dorsal and anal are triangular acuminate in shape, with delicate rays which at first are somewhat distantly articulated, the joints being ornamented with one or two longitudinal sulci. The pectorals are not seen in either specimen, but the smaller of the two shows a well-preserved ventral, which is pretty large, and acuminate in shape.

The scales are best seen in the smaller specimen, and are rather large for the size of the fish, one from the middle of the flank measuring $\frac{3}{32}$ inch in height by $\frac{1}{16}$ in breadth. Over most of the body they are higher than broad, but behind the dorsal fin they become more equilateral and obliquely rhomboidal. The anterior covered area is very narrow; the sculpture of the exposed part is peculiar, and different from that in any other Carboniferous Ganoid with which I am acquainted. Taking one of the flank scales, its external glittering surface is ornamented by delicate wrinkles, a few of which run parallel with the anterior margin, while behind these and over the greater part of the surface they run in an antero-posterior direction, ending in delicate denticulations of the hinder margin; anteriorly, however, these transverse ridges and furrows do not run parallel with each other, but tend to converge in two or three groups. This ornament becomes less marked in the scales behind the dorsal fin, the vertical striæ disappearing, and the scale appearing marked only with a few irregular horizontal furrows; the delicate denticulation of the posterior is, however, preserved as far as the tail pedicle, where the specimen is broken off.

Remarks.—The form of the scales, and the structure and position of the ventral, dorsal, and anal fins, induce me to class this little fish as an *Elonichthys*, though unfortunately the character of the dentition, and the form of the pectoral fin are unknown, while the bones of the head are not in a condition to be described. As a member of this genus it is distinguished by its rather slender form, and proportionally large scales, with their peculiar ornament.

Geological Position and Locality.—From the Dalemoor Rake Iron-stone, Lower Coal-measures, Stanton, Derbyshire, where it is associated with *Elonichthys Aitkeni*, Traq.; *Platysomus tenuistriatus*, Traq.; and *Mesolepis micropterus*, Traq. The two specimens which have served for the above description are in the collection formed by the late Mr. E. W. Binney, of Manchester, who lent them to me some years before his death. The notes, taken of them at that time, are now for the first time published, and the drawings will appear in the continuation of my Monograph on the Carboniferous Ganoid Fishes of Great Britain.

Gonatodus Molyneuxi, Ward, sp. MS.

The largest specimen of this little fish which I have seen is scarcely more than three inches in length; the shape is fusiform, rather "stumpy"; the length of the head is contained about $4\frac{1}{2}$ times in the total. Cranial roof bones ornamented with closely placed, contorted, thread-like ridges; jaws armed with apparently one row of comparatively stout stylo-conical bluntly-pointed teeth, which are slightly incurved towards the apex. Scales proportionally large; covered surface narrow; exposed surface, in the flank scales, marked in front with a few exceedingly delicate vertical grooves or striæ turning round below parallel with the lower margin, the rest of the surface being marked posteriorly with nearly equally minute transverse striæ ending on very delicate denticulations of the hinder

margin—a nearly smooth space being left between the last set of striæ and the vertical ones along the front. The scales become smaller and more oblique posteriorly, the striation fading away, though the marginal denticulation remains as far back as the caudal fin.

The fins are not very well preserved in any of the specimens I have seen. The pectorals are not visible; the dorsal is nearly opposite the interval between the ventrals and the anal; the caudal is of course heterocercal. All seem to be rather few-rayed; rays comparatively coarse with distant articulations, the joints being smooth, or ornamented with one or two delicate sulci.

Remarks.—This well-marked species was discovered, and recognized as undescribed, by Mr. Ward, F.G.S., of Longton, who confided to me the specimens for description, with the request that I would name it *Molyneuxi*, after his friend, the late Mr. Molyneux, well known as a collector of North-Staffordshire Carboniferous fossils. It is the same fish which in my essay on the structure of the Palæoniscidæ I alluded to as *Microconodus Molyneuxi*, and only the desire to avoid excessive multiplication of genera induces me to withdraw "*Microconodus*" for the meanwhile. The species has undoubtedly certain obvious resemblances to the common Lower Carboniferous genus *Gonatodus*, but the teeth do not seem to exhibit that second flexure at the apex so characteristic of at least the type species *G. punctatus*, Ag. sp. From the Lower Carboniferous species of the genus it is furthermore distinguished by the greater comparative size of the scales and the coarseness of the fin rays.

Geological Position and Locality. — Deep-Mine Ironstone, Coal-measures, Longton, Staffordshire. In the Collection of Mr. Ward.

Rhadinichthys Planti, sp. nov. Traquair.

The most perfect specimen I have seen measures $2\frac{1}{8}$ inches in length by $\frac{7}{10}$ in greatest depth; its shape is therefore elegant and slender. The head measures $\frac{9}{12}$ inch in length, and is contained nearly 5 times in the total; the dorsal fin commences $1\frac{1}{4}$ inch behind the tip of the snout, and the lower lobe of the caudal $1\frac{3}{4}$ inch behind the same point, the anal being exactly opposite the dorsal. The pectorals are not exhibited in any specimen I have seen, but traces of a ventral are seen in one case midway between the anal and the shoulder-girdle.

The head shows a *peculiarly large development of snout*, forming a considerable bluntly-pointed prominence over the mouth. The cranial roof bones are ornamented with incised furrows, producing a comparatively coarse flattened ridging between them. The suspensorium is oblique, the operculum is broad, but with its inferior margin sloping obliquely upwards so as to make an acute angle with the anterior, and an obtuse angle with the posterior one. Correspondingly the superior margin of the suboperculum slopes very obliquely upwards and backwards, its anterior margin is short, and the posterior one long and rounded. The upper limb of the

preoperculum is broad and triangular, the lower one narrow. I see no markings on these opercular bones save a few concentric striæ. The maxilla is of the ordinary palæoniscoid shape, but in none of the specimens are its markings clearly shown. The mandible is comparatively short, and is ornamented by prominent ridges which run obliquely forward so as to touch the upper or dentary margin at very acute angles.

The scales are small, rhombic, and with the usual palæoniscoid mode of articulation. It is extremely difficult accurately to make out the character of the outer surface, which seems to be ornamented with excessively minute and faintly marked ridges and furrows, bearing obliquely downwards and backwards over their surface.

Remarks.—I place this strange little Palæoniscid, whose specific characters are so strongly marked, only provisionally under *Rhadinichthys*; and probably a new genus will ultimately have to be established for it, characterized by the more than usually prominent snout and the dorsal being exactly opposite the anal fin, characters in which I must own it differs from the typical species of *Rhadinichthys*.

Geological Position and Locality.—Coal-measures. The best specimens I have seen are in the collection of Mr. John Plant, of the Royal Museum, Salford, who obtained them from Colleyhurst near Manchester; others, less perfect, are in the collection of Mr. Ward, of Longton, who collected them from the Deep-Mine Ironstone of that locality. Burnley, Lancashire, collected by Mr. G. Wild.

I have pleasure in naming this species after Mr. Plant, who has always been most liberal in affording me access to the specimens of Coal-measure Fishes in his collection.

Acrolepis Wilsoni, sp. nov., Ward, MS.

Exposed surface of scale $\frac{5}{6}$ inch in height by $\frac{7}{24}$ in breadth: rhombic, closely covered with small pits about $\frac{1}{144}$ inch in diameter, which in the middle of the area are arranged quite irregularly, but above and below are disposed in three or four regular lines parallel with the upper and lower margins respectively. The surface between the pits is minutely fretted with excessively delicate grooves, only perceptible by aid of a lens.

The well-developed covered area projects upwards in an angular process, the articular spine is strongly marked.

Remarks.—The scale described above was collected by Mr. E. Wilson, F.G.S., from the Yoredale Shales of Turnditch, near Belper, Derbyshire, and recognized as new by Mr. Ward, of Longton, through whose intermediation it came into my hands for description.[1] The shape of the scale indicates *Acrolepis* as its genus, but the pecularity of its markings entitles it to specific distinction, and accordingly, at the request of Mr. Ward, I name it *Acrolepis Wilsoni*.

[1] Since the period here referred to, the scale has come into the possession of the British Museum.

III.—On a Limestone with Concentric Structure from Kulu, North India.

By C. Davies Sherborn, F.G.S.

In the Thirty-Sixth Annual Report on the New York State Museum of Natural History (8vo. Albany, 1884), is a folding plate with a fly-leaf descriptive of a specimen with peculiar structure from the Calciferous Sandstone group of Greenfield, Saratoga Co. It is referred to a new genus and species under the name of *Cryptozoon proliferum*,[1] but no author's name appeared to either the plate or the description.[2] The peculiar appearance of the American figure reminded Prof. Rupert Jones of a specimen in his collection, and having kindly placed it in my hands and permitted me to bring it before the notice of the readers of the Geological Magazine, he has given it to the British Museum. Prof. Jones's specimen was collected by the late John Calvert, F.G.S., the author of "Vazeeri Rupi, the Silver Country of the Vazeers in Kulu,"[3] and the rock is referred to at p. 8 of that book. The specimen was shown by Mr. Calvert to Sir Warington W. Smyth (whose opinion as to its inorganic nature is quoted by Mr. Calvert), and afterwards given to Prof. Jones. At first sight it very much resembles the figures of the American fossil. It consists of an oblong slab, $4 \times 2\frac{1}{2} \times 1$ ins., showing in its centre a round or rather oval concretion, the matrix being dark slate-coloured limestone, similar in general appearance to our Carboniferous Limestone. One face of the slab has been cut through the centre of the round mass and the other face half-way between the centre and the periphery. The concentric structure occupying nearly the whole of the surface of the slab (as may be seen in the accompanying Figure) touches one side; and only the corners of the slab show the undisturbed bluish matrix. The rings are of many shades of grey, with a few of an orange-pink colour passing into brown. On two sides of the face of the slab are indications of other concentric masses, and with one of these the example in question appears to have been joined, as it shows a tendency to assume a pear shape, with a "point below" the root or starting-point of growth—as in the description of the figures of the American form.

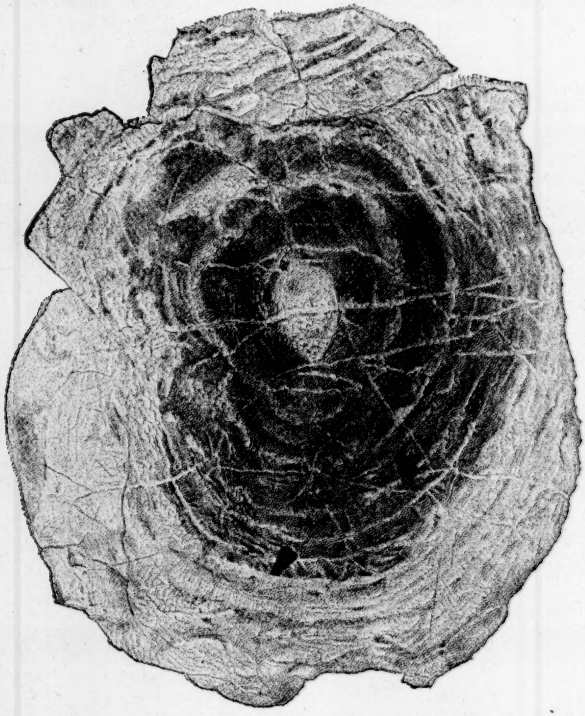
It seems certain that the American specimens are of organic origin, for we are told that "the substance between the concentric lines in well-preserved specimens is traversed by numerous, minute, irregular canaliculi, which branch and anastomose without regularity," and that "the central portions of the [concentric] masses are usually filled with crystalline, granular, and oolitic material, and many specimens show the intrusion of these extraneous and inorganic substances between the concentric laminæ." In the Indian specimen

[1] Since this paper was written and handed in to the Geol. Mag. another note on *Cryptozoon* has been published in the 14th Ann. Rep. Geol. N.H. Survey, Minnesota, for 1885, 8vo. St. Paul, 1886.

[2] The authorship of this paper has been referred to Dr. James Hall, of Albany.

[3] 8vo. London and New York, 1873.

there are neither of these evidences; but the last few regular rings—of a pale ash-grey colour—are crowded with straight or slightly curved fibre-like markings, rarely bifurcating, sometimes solitary and sometimes in bundles. They are indicated by white linear streaks, and under the microscope are seen to be minute cracks through the layers. They do not radiate from the centre of the mass, and are apparently quite independent of the original crystallization; for in some instances they are tangential to the series of rings. In some of the darker rings, radial crystallization is well marked, round the outer edge, and we can see distinctly that such layers would, if their



Section of a concentric mass, probably of organic origin, imbedded in dark-coloured limestone, from Kulu, Central Himalayas.

surface were exposed, exhibit a mammillated appearance. The fibre-like cracks and the radial crystallization are both too fine to show in the Figure, which represents the specimen about natural size; but their position is indicated by the black triangles. The centre is a woolly-looking oval mass, three-quarters of an inch in its longest diameter, of a pale-grey colour, and may owe its appearance to its being semitranslucent and crystalline.

We have neither granular nor oolitic material visible in the Indian specimen. Cracks run through it in several directions; but these

are filled up with white crystalline infiltrations. One of these fissures, passing right through the central portion, gives off there a small quantity of a brown fluffy material, perhaps ferruginous.

No organic tissue seems to be traceable; and with this view it is interesting to find an inorganic so closely resembling an organic structure. It might well pass for *Cryptozoon* were the figure only of that form known to us, without its detailed description.

The specimen has now been deposited in the British Museum (Natural History), where a section has been cut from the face of the mass, so as to permit of a more exact examination of its structure.

The following is an extract from a letter to the Editor received from Prof. H. A. Nicholson, D.Sc., F.G.S., and gives the expression of his opinion after an examination of the Kulu limestone:—

"I have made a careful examination of the slide of the 'Kulu' specimen which you sent me, so far as its condition allows. I am not prepared to give any *positive* opinion about it, but have no hesitation in saying that, so far as I can judge, it is certainly *organic*; but that the organism (whatever may have been its nature) has been subjected, subsequently to entombment, to great alteration by pressure and crystallization. I have seen and examined very similar specimens, from both Silurian and Devonian strata, where one had unquestionably to deal with an organism, but where precisely similar alterations had taken place. Thus, masses of *Heliolites Grayæ* and *Heliolites porosa* often occur in this condition. Stromatoporoids also very often. Some of the things which M. Dupont has described from the altered Devonian Limestones of Belgium under the name of *Stromatactis* are of a *very* similar character. I have examined specimens of these, and while some appear to be due to a peculiar crystalline structure produced by inorganic causes, others seem to be certainly organic, and to be due to the action of pressure and crystallization, upon such organisms as *Heliolites porosa* and some of the Stromatoporoids. So far as your 'Kulu' specimen goes, I should not like to be dogmatic either way, but it is (to say the very least) *quite* as likely to be an altered fossil as a mere concretion. It shows, in fact, some features which would strongly incline me to the view that it is the former.—Aberdeen University, Feb. 20th, 1888."

IV.—On a Hornblende-Hypersthene-Peridotite from Losilwa, a low hill in Taveta District, at the S. Foot of Kilima-njaro, E. Africa.

By Frederick H. Hatch, Ph.D., F.G.S., H.M. Geological Survey.

A SMALL series of rock-specimens, consisting chiefly of fragments of basalt, dolerite, volcanic conglomerate and tuff, which were collected near Kilima-njaro, by F. Holmwood, Esq., C.B., late Consul-General at Zanzibar, was recently forwarded to the Museum at Jermyn Street, and placed by Dr. A. Geikie in my hands for determination. Among these specimens was a small block, the crystalline texture and high density of which at once arrested attention

Freshly fractured surfaces of this rock present numerous glistening facets, which with the aid of the pocket-lens are seen to be the cleavage-faces of a yellowish-green, a dark-green, and a garnet-red mineral. These minerals are respectively olivine, hornblende, and hypersthene in nearly equal proportions, the hornblende being perhaps slightly predominant. They form a holocrystalline granular aggregate, in which the grains are of nearly equal size and without crystalline contours; in other words, the structure is *allotriomorphic-granular*. Subordinate both in size and quantity to the three principal constituents is magnetic iron-ore.

A rude foliation or banding, which is only just perceptible in the hand-specimen, is rendered apparent under the microscope by a tendency to uniform orientation of the constituents, more especially of the hornblende-grains. This seems to indicate that the rock, like many other peridotites, constitutes, *in sitû*, an integral part of a banded crystalline series—an assumption which by no means excludes the possibility of igneous origin.[1]

Under the microscope a brilliant picture is produced by the contrast between the bright grass-green of the hornblende and the beautiful salmon colour of the hypersthene, the olivine-grains being colourless. On rotating the section in polarized light (without the upper Nicol) the striking pleochroism of the hypersthene becomes visible. In order to determine the colour of the rays vibrating parallel to the different axes of elasticity, sections were sought in which the cleavage-lines intersected at an angle of about 90°. Such sections present, in convergent polarized light, the emergence of an axis of least elasticity (γ). In parallel light the colours of the rays vibrating parallel to α and β can be determined. They are:—

α=*rich salmon-red.*
β=*very pale yellow* (almost colourless).

Sections which have only one set of cleavage-lines extinguish straight, and give for rays vibrating in this direction (γ) the characteristic *pale sea-green* colour.

Thus we have $\alpha > \gamma > \beta$.

The hornblende, which is of a rich green colour, is chiefly remarkable for the imperfection of its cleavage-cracks, these being not nearly so sharply defined as is usual in this mineral. Its relation both to the olivine and to the hypersthene shows that the hornblende was the last product of consolidation. It is found, for instance, enclosing grains of both hypersthene and olivine—a structure which, when more largely developed, produces the 'lustre-mottling' described by Williams and others. The pleochroism, which is marked, is as follows:—

α=*pale yellow.*
β=*yellowish green.*
γ=*bluish green.*
$\gamma > \beta > \alpha$.

[1] Thomson ("Through Massai-Land," London, 1885) repeatedly mentions the occurrence of metamorphic rocks in this neighbourhood. They are seen, according to

The olivine is perfectly fresh and consequently colourless. High magnification discloses, both in this mineral and in the hornblende, the presence of parallel rows of opaque rod-like enclosures. The freshness of the minerals that contain them seems to preclude the idea of these bodies being of secondary origin.

The iron-ore occurs in irregular opaque grains which are easily attracted, and removed from the powdered rock, by a small bar-magnet. These grains are often edged by irregular plates of a translucent green mineral, which also occurs in isolated grains, or included in the hypersthene. In the latter case it sometimes assumes an octahedral form. It is isotropic and belongs probably to the spinell-group (pleonast or hercynite).

With regard to the name applied to this rock, its right to a place among the peridotites is at once established by its high density (sp. g.=3·3), the complete absence of a felspathic constituent, and the presence of a considerable proportion of olivine; although the latter is not the dominant constituent. Were the classification advocated in the new edition of Rosenbusch's "Physiographie der massigen Gesteine"[1] to be followed, the rock would have to be referred to the hornblende-picrites. Since, however, it bears no resemblance in structure and composition either to the rocks to which Tschermak originally gave the name picrite, or to those, for which 15 years later Prof. Bonney proposed the name hornblende-picrite, I do not feel justified in adopting these terms. Indeed no small confusion seems to have been caused, here as in other cases of rock-nomenclature, by the modification in the meaning of a term, the extension of which has been clearly limited by its originator.

The name picrite was given by Tschermak,[2] in 1866, to crystalline rocks which are intrusive in the limestones and sandstones of the Cretaceous and Eocene formations of the highlands between Neutitschein, Teschen, and Bielitz, in Moravia and Silesia. These rocks are described as consisting "to the extent of one half of crystals and grains of olivine; further of a lime-felspar, together with diallage, which can be replaced by hornblende, augite or biotite. The texture is porphyritic, with regard to the olivine, or finely granular." . . . . "Picrite bears the same relation to olivine-gabbro as basalt or melaphyre to gabbro."[3] Like basalt it often possesses "an interstitial substance which consists partly of microlites, partly of a structureless isotropic glass."[4]

Later on we find Gümbel[5] applying the term *palæopicrite* to altered rocks which consisted originally of olivine, pyroxene, and a small

this author, to crop out at the very foot of Kilima-njaro on the E. and S. sides. O. Mügge (Neues Jahrb. B.B. iv. 1886, p. 576) has described gneissose mica-schists and amphibolites from the southern portion of Massai-Land, as constituting members of a "gneiss or granite-gabbro formation."

[1] 1887, p. 260.

[2] Sitzungsber. K. K. Akad. der Wissensch. Wien, 1866, Bd. liii. p. 260.

[3] Sitzungsber. K. K. Akad. der Wissensch. Wien. 1867, Bd. lvi. p. 274.

[4] Die Porphyrgesteine Oesterreichs, etc. Wien, 1869, p. 245.

[5] Geogn. Beschreib. des Fichtelgebirges, Gotha, 1879, p. 150.

quantity of plagioclase and brown mica. The new word was scarcely wanted; but still an intelligible use can be made of it, if it be noted that the palæopicrites bear the same relation to the diabases that the picrites do to the basalts. In short the palæopicrites are olivine-diabases in which the felspar is quite subordinate. In this country we have as examples of typical palæopicrites, the Blackburn and Inchcolm rocks, described by Dr. A. Geikie.[1]

In 1881 Prof. Bonney[2] proposed the subdivision of the picrites into hornblende-picrite and augite-picrite, according as the dominant bisilicate is hornblende or augite. Adopting this subdivision, Rosenbusch, in his new edition, has defined the hornblende-picrites as peridotites which consist essentially of olivine and hornblende, and the picrites as peridotites which consist essentially of olivine and augite, the term peridotite being restricted to "plutonic rocks (*Tiefengesteine*) with hypidiomorphic-granular structure and characterized by the absence of felspar and the presence of abundant olivine." This, it will be seen, is a considerable change in the meaning originally attached by Tschermak to the term picrite; and the latter, as defined by Rosenbusch, admits of considerable variation in structure and affinities. On the other hand, Tschermak's picrites (*e.g.* that from Gümbelberg near Neutitschein) have been relegated to a new group, viz. that of the "picrite-porphyrites."[3]

The conclusion to be drawn from these digressive considerations is that the picrites (or palæopicrites) are olivine-augite rocks which possess affinities with, and pass, by an increase in the amount of felspar, into dolerites (or diabases) and basalts; while the hornblende-picrites, on the other hand, appear to be rocks which possess affinities with, and pass into, diorites.

The peridotite from Kilima-njaro, described above, contains no trace of felspar, has a specific gravity of 3·3, is holocrystalline and granular, and exhibits indications of foliation—characters which are incompatible with those of the picrite group. It bears, however, some resemblance to the hornblende-peridotites of Peekskill, Hudson River, N.J., described by G. H. Williams;[4] and I have therefore followed his system of nomenclature. If a distinctive name were really requisite, the name Cortlandtite, suggested by Williams for these rocks because of their relation to the Cortlandt series of Dana, might be adopted.

Mr. Teall has shown me peridotites from Scourie in Sutherlandshire, which bear a still more striking likeness to the Kilima-njaro rock.[5]

[1] Trans. Roy. Soc. Edin. vol. xxix. (1880), p. 504.
[2] Q. J. G. S. vol. xxxvii. (1881), p. 137.
[3] Physiog. der Massig. Gest. 1887, p. 518.
[4] Amer. Journ. of Sci. vol. xxxi. 1886, p. 26.
[5] These Scourie rocks are placed by Rosenbusch among the hornblende-picrites, *l.c.* p. 267.

V.—On the Humerus of *Euclastes*.

By Louis Dollo, C.E.;
Assistant Naturalist in the Royal Museum of Natural History of Belgium, Brussels.

I.—To avoid useless repetitions, I shall consider as admitted what I have said in my paper "*Sur le genre Euclastes*,"[1] especially:

1. *Euclastes*, Cope = *Chelone*, Owen (non Ritg.) (pars) = *Lytoloma*, Cope = *Puppigerus*, Cope (pars) = *Glossochelys*, Seeley = *Pachyrhynchus*, Dollo = *Erquelinnesia*, Dollo.

2. The diagnosis of the *Propleuridæ*, as I have completed it.

II.—This being stated, I think that the far more chelydroid than chelonoid humerus of the above-named Turtles is one of the most interesting facts of their organization. Indeed, if we remove, for the present, from the Dactyloplastrine Cryptodiran Thecophorian Chelonians:[2]

1. The *Trionychidæ*, with which the *Propleuridæ* have nothing in common, as is sufficiently proved particularly by their carapace and their plastron;

2. The *Propleuridæ* themselves, since it is precisely these which we are comparing with the others; we have only really to examine the two following types:

1. The *Chelonidæ*;
2. The *Chelydridæ*.

Now, by their skull[3] and their procœlous caudal vertebræ,[4] the *Propleuridæ* are related to the first-named family. Their carapace and their plastron would, it is true, appear to place them nearly at an equal distance between the *Chelonidæ* and the *Chelydridæ*, especially on account of the degree of ossification. Nevertheless, as the nuchal bone does not possess the characteristic costiform process of the latter,[5] I think that we should not be justified in regarding the structure of the carapace and plastron as a sign of relationship with the last-mentioned family; it is a question, in the case which we are considering, of a simple coincidence in two parallel series. The *Propleuridæ* might then be looked upon as aberrant *Chelonidæ*, ranking

[1] L. Dollo, "Sur le genre *Euclastes*," Société géologique du Nord, Annales xv. 1887-88 (*in the press*).

[2] L. Dollo, "Première Note sur les Chéloniens du Bruxellien (Eocène moyen) de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg., t. iv. 1886, p. 84.

[3] R. Owen and T. Bell, "Monograph on the Fossil Reptilia of the London Clay," part i. *Chelonia*, Palæontographical Society, 1849, pp. 9 and 10; E. D. Cope, "Synopsis of the Extinct Batrachia, Reptilia and Aves of North America," Trans. Amer. Phil. Soc. Philadelphia, 1871, vol. xiv. p. 148; L. Rütimeyer, "Ueber den Bau von Schale und Schädel bei lebenden und fossilen Schildkröten als Beitrag zu einer palæontologischen Geschichte dieser Thiergruppe," Verhandl. d. naturforsch. Gesellschaft in Basel, vol. vi. 1874-78, p. 122.

[4] L. Dollo, "*Euclastes*," etc. (*loc. cit.*). It is known that, in the *Chelydridæ*, the caudal vertebræ are opisthocœlous (E. D. Cope, "The Vertebrata of the Tertiary Formations of the West," Rep. U.S. Geol. Surv. Territ. (F. V. Hayden), 1884, p. 111).

[5] G. Baur, "Osteologische Notizen über Reptilien," Zoologischer Anzeiger, 22 Novembre, 1886, p. 688; R. Lydekker and G. A. Boulenger, "Notes on Chelonia from the Purbeck, Wealden, and London Clay," Geological Magazine, June, 1887, p. 273; L. Dollo, "Première Note sur les Chéloniens oligocènes et néogènes de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg. t. v. 1888, p. 92.

as a subfamily, my *Pachyrhynchynæ*,[1] did not their peculiar humerus show us a type having limbs wholly different from those of the *Chelonidæ*, and even to such a degree that, on account of them, it is necessary to create a distinct family, the *Propleuridæ* of Mr. E. D. Cope.[2]

III.—We will now proceed, more in detail, to the study of the humerus in question:

1. To show, first, that it is really more chelydroid than chelonoid;
2. Then, as it might be doubted, we shall demonstrate that it really belongs to the Turtle to which we ascribe it;
3. Lastly, we shall draw from our observations the conclusions to which we shall be led, notably with regard to Phylogeny.

IV.—To begin with, we shall compare the humerus of *Chelydra* to that of *Chelone*; we shall find:[3]

Characters.	Chelydra (Fig. 1).	Chelone (Fig. 3).
1. General form.	Elongated, sigmoid. Section, at the narrowest point, distally to processes, elliptic, but differing slightly from a circle.	Less elongated, rectilinear. Section, at the narrowest point, distally to the process, more or less elliptic, but very flattened.
2. Head. (*g.*)	Longest axis very oblique on the longest axis of the distal end.	Longest axis perpendicular to the longest axis of the distal end.
3. Mesial process. (*i.*)	Hardly rising above the head, *when the longest axis of the humerus is vertical.*	Rising very much above the head, when the longest axis of the humerus is vertical.
4. Lateral process. (*h.*)	Placed close to the head.	Clearly detached from the head and placed nearer to the distal end.
5. Intertubercular fossa.	Placed close to the head, with the longest axis perpendicular to the longitudinal axis of the humerus, and wedged in between the lateral and mesial processes.	Less well circumscribed, oblique, with the greatest axis nearly directed according to the longitudinal axis of the humerus, extending towards the distal end.
6. Condyles. (*a*, *b*.)	Well marked, and forming nearly the whole of the distal end of the humerus.	Forming hardly half the distal end of the humerus; displaced mesially.
7. Ectepicondyle. (*d.*)	Hardly developed.	Much more developed; it causes the condyles to be displaced mesially.
8. Ectepicondylar foramen. (*e.*)	Missing; replaced by a groove.	Present, but placed nearer to the longitudinal axis of the humerus than the groove of *Chelydra*.

V.—But:

1. By its general form;
2. By its head;
3. By its mesial process;
4. By its lateral process;
5. By its intertubercular fossa;

} (Fig. 2.)

[1] L. Dollo, "Première Note sur les Chéloniens landéniens (Eocène inférieur) de la Belgique," Bull. Mus. Roy. Hist. Nat. Belg. t. iv. 1886, p. 139.

[2] E. D. Cope, "Synopsis," etc., p. 235.

[3] L. Dollo, "Chéloniens oligocènes," etc., p. 78.

the humerus of *Euclastes* is of the type of that of *Chelydra* and not of that of *Chelone*.

VI.—Nevertheless, we shall remark that, although being more chelydroid than chelonoid as a whole, the humerus of *Euclastes*;

1. By its curvature less sigmoid and its flatter form;

2. By its head slightly less oblique on the greatest axis of the distal end;

3. By its lateral process less elevated, slightly more detached from the head, and less distinctly perpendicular to the surface on which the orifice of the ectepicondylar foramen is situated;

4. By its condyles less developed and slightly more displaced mesially;

5. By its more marked ectepicondyle;

6. By the presence of an ectepicondylar foramen;

differs slightly from the type of *Chelydra* and shows an approximation towards *Chelone*.

The foregoing considerations prove, evidently, that, if the limbs of *Euclastes* were infinitely less adapted to aquatic life than those of *Chelone*, they were, however, more so than those of *Chelydra* and perhaps even than those of *Trionyx*.[1] But we shall return to this subject further on.

VII.—Does the humerus referred to *Euclastes Gosseleti*, Dollo, belong really to that Turtle? I think so; because:

1. The fossil Vertebrates of the Erquelinnes sandpits were sent to the Museum of Brussels in separate parcels containing bones imbedded in sand. Each parcel included the remains of one specimen. Now, we have got two humeri appertaining to the same side (therefore from distinct individuals), and each of them came in its own parcel containing exclusively bones of *Euclastes*; I shall also add that they were sent at different times;

2. The humeri agree in size with the accompanying skeletons;

3. They are also in the same state of fossilization, they have the same aspect;

4. If they should not be admitted to belong to *Euclastes*, taking into consideration the Chelonian fauna of Erquelinnes, there would only remain to look upon them as *Trionyx*; but:

A. They are of too large a size to have appertained to the skeletons of *Trionyx* of which carapaces have as yet been found at Erquelinnes;

B. They are also too dark in colour;

C. They offer besides differences from *Trionyx* in the general form, the head, the lateral process, the intertubercular fossa, the condyles, the ectepicondyle, and the presence of an ectepicondylar foramen;

5. Moreover, *Euclastes* is so abundant at Erquelinnes comparatively with other Chelonians (certainly 10 to 1 with respect to *Trionyx*) that:

A. If the humeri had been found isolated, which is not the case;

[1] On account of the distal extremity of the humerus, and the metapodials (or phalanges) which seem devoid of condyles, as has already been observed by Mr. E. D. Cope (Tertiary Vertebrata, etc., p. 111), and as I have also noticed (L. Dollo, *Euclastes*, etc., *loc. cit.*).

B. If their size corresponded equally with that both of *Trionyx* and of *Euclastes*, which is not the case;

C. If the fossilization, and especially the colour, had been the same, which they are not;

they ought still, according to the law of probability, to be referred to *Euclastes*;

6. Lastly, on the other side of the Atlantic, Mr. E. D. Cope has made known, a long time ago,[1] that the Cretaceous *Propleuridæ* had a more chelydroid than chelonoid humerus, and he was so much impressed by this structure, amongst others, that he began by placing with the *Chelydridæ* the genera which have since composed his *Propleuridæ*.

After what has been said above, it seems to me beyond doubt that the humeri described as belonging to *Euclastes* really appertain to that genus.

However, a further verification, which I am going to mention, appears to me possible. The Erquelinnes Chelonians are imbedded in sand, consequently in a matrix devoid of cohesion; on the contrary, the London Clay Chelonians, several of which ought certainly to be classed among the *Propleuridæ*,[2] are found not only in clay, a more coherent substance, but each of them is said to be included in a "nodule of petrified clay."[3] Under these conditions, the latter show with more certitude the bones which come from the same individual. Now, *Chelone longiceps*,[4] Owen, is one of the types belonging to the *Propleuridæ*, as I understand them, and the skull, the carapace, as also the humerus, are still adhering together.[5] If, then, the humerus is of the shape of our Fig. 2 (*Euclastes Gosseleti*, Dollo), the above-mentioned verification will be made. Therefore, it is to be wished that an English naturalist should consent to examine this point; and it is precisely to make known this desideratum that I have chosen the pages of the Geological Magazine to publish the present paper. I am aware that Sir R. Owen says, speaking of the humerus in question: "The humerus presents the usual characters of that of the *Chelones*."[6] But the celebrated naturalist may not have had his attention especially drawn to this bone; moreover, judging by the figure which he gives of it,[7] it appears to me somewhat mutilated, as also imperfectly cleared of its matrix. I shall add that it is not one specimen only that should be studied, but all those coming from the London Clay, which can be referred to *Propleuridæ*, and in which the humerus is associated, beyond a doubt, with other characteristic remains.

VIII.—It ought to be inferred from the preceding pages that the *Propleuridæ* were Turtles not so well adapted to an aquatic life as

[1] E. D. Cope, "Synopsis," etc., pp. 130 et 235.
[2] L. Dollo, "Chéloniens landéniens," etc., p. 137; R. Lydekker and G. A. Boulenger, "Notes on Chelonia," etc, Geol. Mag. p. 271.
[3] R. Owen and T. Bell, "Monograph," etc., p. 40.
[4] R. Owen and T. Bell, "Monograph," etc., p. 16.
[5] R. Owen and T. Bell, "Monograph," etc., pl. iv.
[6] R. Owen and T. Bell, "Monograph," etc., p. 17.
[7] R. Owen and T. Bell, "Monograph," etc., pl. iv.

true *Chelone*. Since the first Chelonians were certainly terrestrial,[1] and that the *Propleuridæ* are, especially as far as the limbs are concerned, nearer to the primitive stock of the *Testudinata* than the living *Chelone*, it may be inquired whether these *Propleuridæ* are not the direct ancestors of the latter. I do not think so, for the following reasons. Notwithstanding that the Cretaceous beds[2] containing *Propleuridæ* are, without doubt, older than the Cretaceous beds[3] in which the oldest true *Chelone*[4] has been found, and that, consequently, in the present state of knowledge, there is no contradiction so far, as to time, I am of opinion that the structure of the mandible[5] suffices alone to make us consider that descent as impossible. Indeed, a short symphysis is primitive, a long one derived. Therefore, it is not at all likely that the latter has given rise to the former. Moreover, the carapace, the plastron, and the choanes[6] point also in the same direction.[7]

IX.—But, without being the direct ancestors of the *Chelonidæ*, the *Propleuridæ* may enlighten us as to these ancestors, just as *Hesperornis*,[8] which, on account of its much reduced wings, could not be the precursor of any of the living Birds, throws light on the dentition of the forms from which they have been derived. The *Propleuridæ* show us the large head,[9] the separated nasals,[10] and the more terrestrial limbs possessed at one time by true *Chelone*. Thus, Palæontology furnishes material proof of facts already foreseen by Morphology.

X.—According to Mr. E. D. Cope,[11] the relations between the Dactyloplastrine Cryptodiran Thecophorian Chelonians are the following:

Chelydridæ.
|
Propleuridæ.
|
Chelonidæ. — *Trionychidæ.*
|
|

I cannot admit this grouping, because:

1. How could the *Trionychidæ* have transmitted to the *Propleuridæ* the marginal bones, which they have lost themselves?

[1] G. Baur, "Notizen," etc., p. 688.

[2] L. Dollo, "*Euclastes*," etc. Because, in England, there is no Danian (A. Geikie, "Text-Book of Geology," p. 815); and, in the United States of America, the fossils found in the *Euclastes*-beds, for instance, *Teredo tibialis* and *Gryphæa vomer*, are considered by D'Orbigny as Senonians (Prodrome de Paléontologie stratigraphique, Paris, 1850–52).

[3] Danian (Tuffeau de Maestricht).

[4] "*Chelone Hoffmanni*," Gray. . . . "Bis jetzt ist dies indessen das älteste Fossil aus Europa, das mit vollem Recht den Namen *Chelone* trägt" (L. Rütimeyer, "Ueber den Bau," etc., p. 119).

[5] L. Dollo, "Chéloniens landéniens," etc., p. 134.

[6] L. Dollo, "Chéloniens landéniens," etc., p. 133.

[7] L. Dollo, "*Euclastes*," etc. (*loc. cit.*).

[8] O. C. Marsh, "Odontornithes; a Monograph on the Extinct Toothed Birds of North America," New Haven, 1880, p. 62.

[9] L. Rütimeyer, "Ueber den Bau," etc., p. 122.

[10] L. Dollo, "Chéloniens landéniens," etc., p. 132.

[11] E. D. Cope, "Tertiary Vertebrata," etc., p. 115.

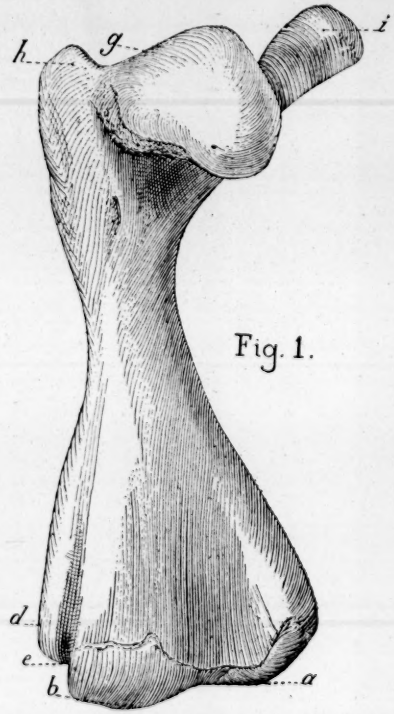


Fig. 1.

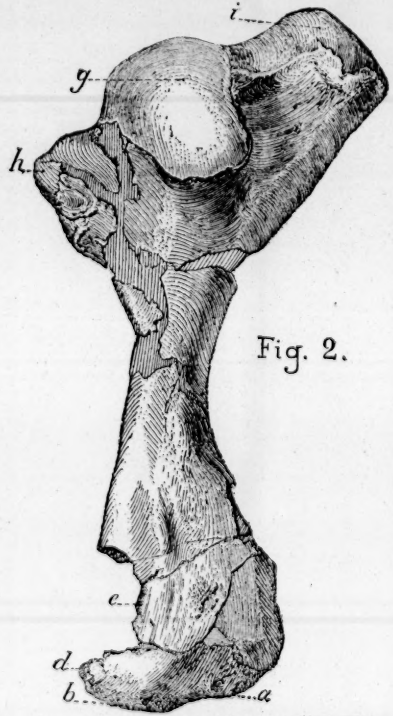


Fig. 2.

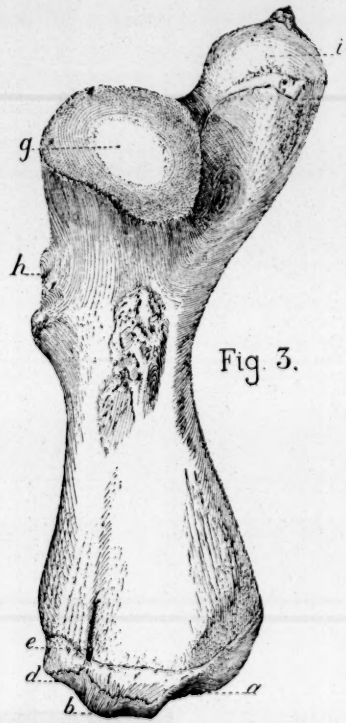


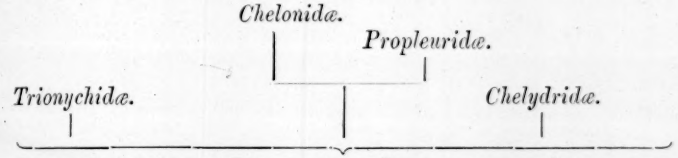
Fig. 3.

Fig. 1.—Humerus of *Chelydra*. Fig. 2.—Humerus of *Euclastes Gosseleti*, Dollo [Lower Landenian (Lower Eocene, *pars*) of Erquelinnes].
Fig. 3.—Humerus of *Chelone*. *a*, entocondyle; *b*, ectocondyle; *d*, ectepicondyle; *e*, ectepicondylar foramen, or ectepicondylar groove; *g*, head of the humerus; *h*, lateral process; *i*, radial process.

2. How have the procœlous caudal vertebræ of the *Propleuridæ* become the opisthocœlous caudal vertebræ of the *Chelydridæ*? Could they have turned themselves the other way? How could the nuchal rib, lost by the *Propleuridæ*,[1] be present in their descendants, the *Chelydridæ*?

3. Whichever might have been the origin of the *Chelonidæ*,[2] their relations with the *Propleuridæ* do not seem to allow of a diphyletic phylogenetic tree for these two families.

XI.—Therefore, we should more likely have:



Dactyloplastrine Cryptodiran Thecophorian Chelonians.

XII.—One more word before concluding. The *Propleuridæ* not being true Turtles, were they pelagic in their habits? The marine nature[3] of the deposit proves nothing in this case, the beds in question containing also *Trionyx*, which, as is well known, lives in rivers.

The humerus of the *Propleuridæ* has already shown us that the limbs of these Chelonians were less well adapted to aquatic life than those of the true Turtles, but that they were more so than those of *Chelydra*, or even than those of *Trionyx*. The metapodials point also in the same direction. As is equally demonstrated by the carapace and diet,[4] *Euclastes* was, therefore, probably a very littoral marine type.

VI.—Woodwardian Museum Notes: on some Anglesey Dykes. No. III.

By Alfred Harker, M.A., F.G.S.,
Fellow of St. John's College, Cambridge.

In the first paper of this series[5] were described several dykes from the shores of the Menai Straits, belonging apparently to one system of intrusions, and some of them cutting Carboniferous strata. Their precise age, however, can be fixed only on the supposition that they may fairly be correlated with certain post-Carboniferous but pre-Permian dykes in the Anglesey Coal-field. These latter rocks have a strong general resemblance to the Menai Straits dykes, and as they are by no means easily accessible, they will not be described in detail. Only one will be selected, as offering a

[1] L. Dollo, "*Euclastes*," etc. (*loc. cit.*).

[2] "On the Relations between *Athecæ* and *Thecophora*," see L. Dollo, "Chéloniens oligocènes," etc., p. 83.

[3] A. Rutot, "Sur la position stratigraphique des restes de Mammifères recueillis dans les couches de l'Eocène de Belgique," Bull. Acad. Roy. Belg. 1881, t. i. p. 22.

[4] L. Dollo, "Chéloniens landéniens," etc., p. 138.

[5] Geol. Mag. Dec. III. Vol. IV. p. 409, 1887. See also *op. cit.* p. 546.

rather pronounced type: the specimen is from the Henslow collection.

[571.] Dolerite from dyke in coal-pit at Llanfihangel. This rock is very fresh and of rather coarse grain: it shows at a glance a tendency to parallelism in the felspars. Magnetite is abundant in the slide, partly in square sections earlier than any other constituent, partly in granular and imperfectly crystalline patches later than the dominant felspar, but included in the augite.

The felspars divide into two distinct generations. The earlier ones occur in well-formed crystals, of elongated rectangular section up to 0·1 inch in length, with a fine distinct twin-lamellation. These lamellæ, sometimes interrupted or discontinuous, correspond to the albite law, but they are often crossed by pericline twinning, and some of the larger crystals exhibit the Carlsbad type also. These earlier felspars have little or no zoning, and seem to be andesine or labradorite. They are, however, not strictly all of one stage, for we may see one crystal moulding another, which in turn encloses a small felspar of still earlier consolidation.

The later generation of felspars differs considerably from the former. The crystals are less elongated and usually shapeless. They are less finely twinned, and the lamellation is rendered indistinct by the strong zonary banding which is made manifest between crossed Nicols. In all these Anglesey dolerites this growth in concentric zones of different optical characters is highly characteristic of the later felspars. It points to a rather rapid change in the chemical constitution of the magma during the closing stages of consolidation, and perhaps depends partly on the almost simultaneous separation of the augite.

In the present rock the augite is not very abundant, and does not build ophitic plates of any great extent. It rarely presents imperfect crystal boundaries to the later felspars, and is on the whole nearly contemporaneous with them. The mineral is pale brown, with the usual prismatic cleavage.

It will be observed that the Llanfihangel rock compares closely with those from the Straits, such, for example, as the Cadnant dyke [545].

Before proceeding further, it may be noticed that there are other dykes in southern Anglesey, which are probably not to be grouped with the foregoing. They differ from them both mineralogically and structurally, and approach more nearly to the characters of parts of the Holyhead dykes to be described below. As an example, a dyke at Bodowen, on the west side of the Malldraeth estuary, is chosen.

[598.] Olivine-diabase of Bodowen. This is an ophitic rock with but one set of felspars. Under a low objective we see first skeletons of ilmenite, clouded with semi-opaque leucoxene, and some crystals of magnetite. There are also numerous rounded light-green patches, in part serpentine, in which are imbedded granules of unaltered olivine. These patches, often included in the augite, are crowded with minute matted fibres, perhaps chrysotile, but more probably

tremolite. Felspar crystals are plentiful, mostly once twinned and with moderately wide extinction-angles in sections perpendicular to the twin-plane. They are moulded and enclosed by large ophitic plates of augite with the characters usually found in that mineral in the Welsh diabases. The edges of these plates are touched here and there with brown hornblende, with the regular crystallographic relations to the augite, and possibly derived from it. Where serpentinous pseudomorphs are included in the augite, there is often a fringe of pale green or colourless amphibole, with a definite crystal orientation projecting into the serpentinous mass. This mineral is no doubt a "secondary enlargement"[1] of the augite crystal from which it grows, though its substance must be derived from the destruction of the olivine.

Holyhead main dyke.—We now pass on to the island of Holyhead, where two large dykes were first noted and described by Henslow. The main one, with an average width of 60 feet, traverses almost the whole length of the island, running in a slightly curved line, but with an average bearing north-west and south-east, from near the South Stack to Cymmeran Bay. It cuts the quartz-rock, the green schists, and the serpentine, occasionally throwing off veins or branches. Henslow carefully notices the contact-alteration of the adjacent rocks, and makes the observation that "where the dyke is contained between parallel walls of the schist, and appears as though it were filling up some large crevice, the effects are never so striking as in those places where it ramifies and becomes intimately associated with the surrounding mass."[2] He also remarks the variability of character displayed in this and the following dyke when traced along their length, a feature still more clearly brought out by an examination of slices under the microscope.

[605.] Olivine-diabase from Porth-dafarch (Port Dafreth of Henslow). The name diabase is employed for this rock, despite a certain approach to the doleritic type, shown by a tendency to develope a second generation of felspars: the structure is ophitic. Olivine grains are abundant and tolerably fresh: they are sometimes slightly penetrated by the felspars. A few imperfect crystals of magnetite are included by the olivine, but the bulk of the mineral is posterior to the dominant felspar. The felspar, apparently labradorite, shows cross-twinning and some zonary shading in polarised light. A few rather shapeless crystals, with strong zoning and less pronounced twin-lamellation, belong to a rather later stage. Pale-brown augite forms large ophitic plates including olivine and felspars alike. The plates are divided by definite lines into distinct fields, with crystalline continuity, but slightly different optical properties, and this structure sometimes approaches the regularity of the well-known "hour-glass augite."

[614.] Dolerite from a small branch of the dyke at the same locality. This rock presents no special peculiarities: if olivine has been present, it is now lost in ill-defined secondary products. The

[1] *Cf.* Van Hise, Amer. Journ. Sci. (3) xxiii. p. 385, 1887.

[2] Trans. Camb. Phil. Soc. vol. i. p. 419, 1822.

structure is distinctly porphyritic as regards the felspars; there is a rather fine-grained ground of ophitic appearance.

[617.] Specimen from the southern part of the dyke, showing the junction of two different rocks. The coarser-grained one is seen under the microscope to be a diabase, partly ophitic, partly granulitic in structure: no evidence of olivine is to be detected.

The finer-grained rock has a ground-mass of minute felspar-microlites and crystals of magnetite, moulded by augite. In this ground are imbedded felspars of rectangular section and a few idiomorphic augites. This rock, which may be styled an augite-andesite, is doubtless a small dyke intruded into the diabase, for it shows a marked fluxional appearance along the line of junction.

Cordier compared specimens from this main dyke of Holyhead Island with the "granitoidal ophites of the Vosges."

Holyhead Eastern dyke.—The second large dyke in the island probably branches off at an acute angle from the main dyke about the middle of its length, and runs in a direction N.W. by N. past the east side of Holyhead Mountain, passing out to sea at the north end with a thickness of 80 feet. Our specimens are from the northern extremity, from Cae Seri on the road to South Stack, and from Bryniau Geirwen on the road to Porth-dafarch. They vary in grain and in general appearance to the eye, some resembling gabbro and others diabase and dolerite. Their intimate structure reveals corresponding variations, but it is perhaps best to class them all together as hornblende-diabases of various types.

Under the microscope all these rocks are seen to contain a rather unusual quantity of apatite in colourless acicular prisms. Magnetite occurs plentifully, in composite crystalline forms, in ragged grains and patches, and in crystal frameworks. These two minerals always have the priority in the order of consolidation.

The augite is of the very pale-brown variety, and when it exhibits crystal outlines, has the familiar octagonal cross-section. Besides the well-defined prismatic cleavage, there are traces of another, transverse to the length of the prism. The mineral is usually fresh; its chief secondary product seems to be serpentine. These characters, which are approached by the augite of many Welsh diabases, agree with the variety malacolite. Hornblende is plentiful in all but one slide [636]. It is the deep-brown 'basaltic' variety, with absorption-formula $\gamma > \beta \gg a$. The mineral occurs sometimes in good prisms, truncated, except in the smallest crystals, by the clinopinacoid. Much of the hornblende, however, occurs in close association with the augite, the two minerals having, as usual, the vertical axis and orthodiagonal common. The hornblende mostly borders the augite, and when there are definite crystal outlines to such a border, they are those proper to the former mineral. This is, therefore, not a case of 'paramorphism,' but an intergrowth of the kind termed *ergänzende* or complementary hornblende. Patches of hornblende in the interior of the augite plates are probably also a parallel intergrowth. The hornblende crystals occasionally enclose grains of augite without any crystallographic

relation, and in all cases the hornblende in these rocks seems to be in the main posterior to the pyroxene. Greenish fibrous amphibole is common as a 'secondary enlargement' in crystalline continuity with the original hornblende, and it sometimes extends as a fringe along the margin of the augite. A similar relation is met with in some of the German hornblende-diabases, *e.g.* the 'proterobase' of Kürenz near Trier.

Striated felspar is always abundant in the rock of the dyke, and appears to belong mainly to the andesine-labradorite series. It is often strongly zoned, or if the felspars do not all belong to one stage, the later ones show this structure. In accordance with the usual rule, the outer zones always give lower extinction-angles than the inner part of the crystal.

The only other mineral to be mentioned is biotite, of which a few flakes are seen in one slide (Bryniau Geirwen). The specimens present then, it is evident, a community of general mineralogical constitution, and the diversity of structure noted below is therefore a matter of some interest.

[626.] From the northern termination of the dyke. In this rock the augite has idiomorphic boundaries, and is moulded by the felspar. The general aspect to the eye is not unlike some gabbros.

A specimen of Mr. Marr's from Cae Seri is a rather coarse-grained gabbro-like rock. The felspar and augite penetrate one another in a rather curious way, and must on the whole have consolidated simultaneously.

[635.] Bryniau Geirwen. This shows the same peculiar type of structure; the augite sometimes presents crystal outlines to the felspar, which moulds it, while in other places these relations are reversed, the felspar crystals penetrating the augite.

[636.] Bryniau Geirwen. This specimen, from the same locality as the last, is an ordinary ophitic diabase.

Finally, a rock procured by Professor Hughes from the same place is also ophitic in structure, but shows a decided tendency to the doleritic type. There are two generations of felspar; one in lath-shaped crystals penetrates the augite and hornblende; the other, more equidimensional and without regular outlines, is of later consolidation than those minerals.

The existence of such wide differences of structure in rocks forming part of one and the same igneous mass, offers a problem of which petrologists have not yet given a complete solution.

Henslow collected specimens from two dykes, the larger one having a width of eighteen feet, at Port Newry, near Holyhead town. As he remarked, the rock here much resembles "the harder portions of the dyke at Port Dafreth" [605]. The chief difference is the greater abundance of olivine.

[638.] Olivine-dolerite of Port Newry. The olivine, which often builds good crystals and has the pinacoidal cleavages well developed, is on the whole the first product of consolidation, though sometimes slightly penetrated, as at Porth-dafarch, by the earliest-formed felspars. The mineral is for the most part pseudomorphed by green

serpentine in the fashion figured by Tschermak[1] and others. The felspar of this rock seems by its extinction-angles to be near anorthite. The most numerous generation is in elongated crystals with fine lamellation. There are also later felspars in shapeless crystals with wide twin-lamellæ and strongly-marked zonary banding in polarised light. The magnetite is later than the dominant felspar and earlier than the augite; it sometimes shows rod-like aggregations of octahedra. The pale-brown augite, in plates with an ophitic tendency, has here again a marked hour-glass structure, although the dividing lines have often an irregular disposition, and even run parallel to the outlines of projecting felspar crystals. It may be remarked that the hour-glass augites of the Welsh rocks rarely exhibit the regularity of structure figured by Werveke, etc.[2]

Several rocks from Holyhead stand on the border-land between the diabases and dolerites, as those families are here defined. The present specimen seems best referred to the latter category, the *porphyrische structur* (Rosenbusch) being well marked: the absence of ilmenite and hornblende is also to be noted in this connection.

Other dykes in Holyhead Island are marked on the Survey Map and mentioned by Sir A. Ramsay. They all strike in a general N.W.—S.E. direction, "which is also that of the fault which crosses Holyhead Mountain between Gogarth and Porth-y-corwgl, and all coincide more or less with the run of many of the larger joints." We have seen that the dykes of the Menai Straits and the Coal-field have about the same bearing, but they show lithologically little resemblance with those last described; and as the rocks cut by the Holyhead dykes are themselves of dubious age, speculation on the date of the dykes must necessarily be reserved.

NOTICES OF MEMOIRS.

I.—A Comparative Study of the Till or Lower Boulder-clay in several of the Glaciated Countries of Europe—Britain, Scandinavia, Germany, Switzerland, and the Pyrenees. By Hugh Miller, F.R.S.E., F.G.S., Assoc.R.S.M.[3]

THE sections of foreign Till examined by the author occur chiefly in the neighbourhood of the Trondhjem Fjord in Norway, at Berlin and Leipzig in Germany, near the Lake of Geneva in Switzerland, and in the valleys of the Pyrenees directly south from Pau in Southern France. In these countries and in Britain the Till bears an identical character. It is not more variable throughout Europe than the author has found it to be in Scotland and Northern England. On the basement-gneiss at Christiansund in South-western Norway it is the same as on the basement-gneiss of Sutherlandshire; in the great limestone valley of Eaux Chauds in the Pyrenees it is scarcely

[1] Sitzungsb. d. k. Akad. d. Wien. vol. lvi. p. 283, and plate, 1867.

[2] Neues Jahrbuch, 1879, p. 823. Hussak, *Anleitung zum bestimmen der gesteinbildenden Mineralien*, p. 72; 1885.

[3] Read at the British Association, Manchester, 1887.

to be distinguished from the Till of the limestone valleys of Yorkshire. In all the places mentioned it bears the unmistakable character of a ground-moraine accreted under the direct weight of glacier-ice. The familiar features of the Till need not be recapitulated here, but the author insists that its essential character is that of a rude pavement of glaciated débris, ground from the rocks over which the glaciers have passed, with its larger boulders firmly glaciated *in situ* on their upper sides in the direction of ice-movement, and with a tendency to the production of fluxion structure here and there in the matrix, due to the onward drag of the superincumbent ice. In mere indiscriminateness of composition (which is the character often most emphasised) the Till is not to be distinguished from Boulder-clays formed under berg- or raft-ice, such as the highest marine clays of the Norwegian coasts, which are stuck promiscuously through with boulders derived from the glaciers of the interior. But the glaciation of boulders *in situ* the author finds to be a really crucial distinction; he readily detected this "*striated-pavement*" character in the Tills of all the districts above mentioned except Leipzig and Berlin, where the Boulder-clays resemble the Upper Boulder-clay (Hessle Clay) of the eastern seaboard of England and Scotland, and in the sections examined by him contained no blocks large enough to take the striæ.

REVIEWS.

I.—The Geological Survey of England and Wales.

SOME time has elapsed since we last noticed a series of the Geological Survey Memoirs (Geol. Mag. for 1886, p. 65), and in the mean time a number of additional Memoirs have been published, attention having been drawn to only one of these (Geol. Mag. 1888, p. 31). Much more detail is inserted in these Explanations of the Survey Maps than was the custom in the earlier publications; but if on this account they afford somewhat heavier reading, they are also much more valuable for reference on questions both of scientific interest and of practical concern. Indeed the precise record of facts and a statement of the localities where particular information has been obtained, are always of great value to subsequent investigators, as well as to engineers and well-sinkers. We note also that the prices of these Memoirs are very moderate.

In addition to a number of General Memoirs on particular districts or rocks, no less than 66 Memoirs explanatory of the Survey Maps have now been published. Nevertheless much remains to be done ere the whole country is described in such detail. Portions of Hampshire and Dorsetshire have not yet been 'explained' in Survey publications; the Isle of Man and the Channel Islands have not at present been officially surveyed; while Cornwall and much of Devonshire, the South Wales Coal-field and the Old Red Sandstone area of Brecknock- Hereford- and Monmouth-shires offer tempting fields for future detailed surveys. Moreover, the Drift-deposits over

considerable portions of the Midland Counties, not to mention other areas, have not at present been mapped.

Our present object, however, is to notice the recent Memoirs, and these will be taken as far as possible in the order of publication.

1. "The Geology of the Country between and south of Bury St. Edmunds and Newmarket." By F. J. Bennett and J. H. Blake; edited with additions by W. Whitaker, F.R.S. 8vo. pp. 27. (London, 1886.) Price 1*s*.

This Memoir contains notices of the Chalk, Glacial Drift, River Gravels, etc. Interesting sections are given, showing the structure of the Glacial deposits and their relation to overlying "Post-Glacial" loam, which has yielded Palæolithic Implements. Numerous well-sections form an Appendix to the work.

2. "The Geology of the Country around Aldborough, Framlingham, Orford, and Woodbridge." By W. H. Dalton, edited (with some additions) by W. Whitaker, F.R.S. 8vo. pp. 59. (London, 1886.) Price 1*s*.

The district described in this Memoir is one of great interest to students of Pliocene geology, including as it does some of the famous Crag-sections near Orford and Aldborough. Mr. Whitaker contributes notes on the fossils and on the literature of the Coralline Crag, but the details given on this formation are confined to two pages, and there is no list of fossils. The accounts of the Red Crag and of the Chillesford Clay are fuller so far as stratigraphical details are concerned, but we miss an account of the fossils. The Palæontology will doubtless be treated in a general Monograph of the Pliocene formation, which we are informed is in preparation.

Short notices of the Chalk, Reading Beds and London Clay, and a more lengthy account of the Glacial Drift, are given, together with notes on the River Gravels, Alluvium, Shingle, and Blown Sand. The well-sections in the area are duly recorded.

3. "The Geology of the Country around Northallerton and Thirsk." By C. Fox Strangways, A. G. Cameron, and G. Barrow. 8vo. pp. 75. (London, 1886.) Price 1*s*. 6*d*.

The rocks described in this area include Millstone Grit, Magnesian Limestone (Permian), Keuper Sandstone and Marl, Rhætic Beds, Lias, Oolites (up to the Kimeridge Clay), Glacial and Recent deposits. The country embraces portions of the Cleveland, Hambleton, and Howardian Hills. The Memoir will be of particular interest to students of Jurassic Geology. Among the strata, the Ironstone series of the Middle Lias is of special economic importance, and detailed sections are inserted to show its mode of occurrence. Lists of fossils are given from the different formations. There is also an Appendix of well-sections, and a list of the more important works referring to the district.

4. "The Geology of the Country around Otterburn and Elsdon." By Hugh Miller. With Notes by C. T. Clough. 8vo. pp. 147. (London, 1887.) Price 2*s*. 6*d*.

This is the first Memoir of the Geological Survey devoted to the Carboniferous Rocks of the English Border, and a full description

has been given of them. Some older rocks are exposed in the area, the Wenlock Beds and Lower Old Red Sandstone (associated with the Cheviot porphyrite), but they occupy small areas, and require but brief notice.

The Carboniferous rocks are grouped as follows:—

- Carboniferous Limestone Series.
  - *Upper Series.* — Calcareous Division.
  - *Lower Series.*
    - Carbonaceous Division (Scremerston Beds).
    - Tuedian Division, or Tweed Beds.
      - Fell Sandstones.
      - Cement-stone Beds & Rothbury Limestones.
      - Lower Freestones.
      - Basement Beds.

The Basement Beds are probably on the horizon of strata elsewhere grouped as Upper Old Red Sandstone. They consist of conglomerates made up of porphyrite and Silurian greywacke. The overlying rocks are described in much detail, many sections being given to show the position of the principal beds of limestone, coal, etc. Separate chapters are devoted to the Faults, and to the Palæontology, the fossils having been identified chiefly by Messrs. G. Sharman and E. T. Newton. Other chapters are devoted to the Igneous rocks, to Glacial Phenomena, Post-Glacial deposits, and to the Physical History of the district. The Economic deposits, Springs, Mineral Waters, etc., are duly noticed, and in Appendices there is an account of the Bibliography, together with a Glossary of Local Terms, and Records of Borings and Sinkings.

5. "The Geology of the Country around Halesworth and Harleston." By W. Whitaker, F.R.S., and W. H. Dalton. 8vo. pp. vi. and 41. (London, 1887.) Price 1*s.*

In this Memoir accounts are given of the Upper Crag (which is rarely fossiliferous in the area), of Chillesford Clay, Pebbly Series, Glacial and Post-Glacial Drift, and Alluvium. The deposits which have attracted most attention are those included as Post-Glacial, the term being used to imply that the beds are newer than the Glacial Drifts of the district. These are the famous Hoxne deposits, which have yielded many Palæolithic implements. Their precise age with reference to the newer Glacial deposits of the north of England may be regarded as an open question: but Mr. Dalton remarks that "The mere presence of land and freshwater shells, bones, and plants would suffice to disprove this correlation with any part of the Glacial series, which is wholly of marine origin." We presume he refers to the Glacial Drifts of Norfolk and Suffolk, but that they are *wholly of marine origin* is very far from being an accepted dogma.

A number of records of well-sections conclude this work; these give accounts of the London Clay, Reading Beds, and Chalk, which are not exposed at the surface.

6. "The Geology of Southwold and of the Suffolk Coast from Dunwich to Covehithe." By W. Whitaker, F.R.S. 8vo. pp. 87. (London, 1887.) Price 2*s.* 6*d.*

Although the area described in this Memoir is a small one (being less than 50 square miles), it is one of considerable interest to students of Pliocene Geology. The cliffs of Dunwich, Easton

Bavent, and Covehithe furnish sections of the Upper Crag (including the Chillesford Beds); these strata are overlaid by a "Pebbly Series," and the question of their precise equivalents in other parts of the country is a debatable one; while above all there are accumulations of Glacial Drift. A well-boring at Southwold, made in 1886-1887, has thrown much light on the underground geology, for it has proved the position of the Chalk at a depth of 323 feet; this is overlain by 70 feet of Reading Beds, 68 feet of London Clay, 147 feet of Crag, and 37 feet of the Pebbly Series.

The thickness of the Crag, as remarked by Mr. Whitaker, is the greatest yet recorded in England, and shows, together with the information obtained through wells at Leiston, Saxmundham, and Beccles, that the formation has a more important development than was suspected a few years ago. Whether this great thickness of Crag should be classed with the Norwich or Red Crag matters little, for, as Mr. Whitaker remarks, they are one formation, and "no useful purpose would be served by troubling about such a question." There is, however, no evidence to show that the highest stage of the Norwich Crag series (such as that represented in the fossiliferous beds of Weybourn and the Bure Valley) is here present, unless it be represented in portions of the "Pebbly Series" that are fossiliferous near Southwold.

The "Pebbly Series," however, presents many difficulties. Much of what is now grouped under this name was originally regarded as Middle Glacial by Messrs. S. V. Wood and Harmer in their Map and Sections of the Crag District, and although Mr. Wood subsequently modified his views, there does not appear to be any definite evidence for the change, and an examination of the Survey Map is not calculated to dispel the notion. These difficulties in correlation are apparent to any one studying the Newer Pliocene and Glacial Deposits of East Anglia, and they are very fully and fairly stated by Mr. Whitaker. He is disposed to regard the Pebbly Series as belonging to one division, and he leaves it an open question whether it should be regarded as Glacial or Pliocene. The shells found in the beds at Southwold are all species known to occur in the Crag; but neither there nor at Dunwich is the Crag separated from the Pebbly Series by the Chillesford Beds which are present in many localities.

On the other hand, where the mass of the Pebbly Series rests on the Chillesford Beds, as seen in the Cliff-sections of Easton Bavent and Covehithe, there is a marked line of erosion between them; while in a section at Henham Park Wood (drawn by the late Mr. S. V. Wood, jun.), the Pebbly Beds are shown to rest on the Chillesford Clay, and tongues of the latter which penetrate the overlying beds are said to have been "lifted up." In reference to this Mr. Whitaker remarks that "The lifting up of masses of this clay and the forcing under them of wedges of the pebbly beds is an occurrence of great interest," and "seems to point also to some lapse of time between the two deposits." We feel, however, some hesitation in adopting the explanation, which is suggestive of Glacial action, for there is no Boulder-clay present.

We should mention that a detailed account is given of the Cliff sections, and this is admirably illustrated by a coloured diagram drawn to scale. The accounts of the coast-deposits and of the waste of the cliffs are also of much interest, careful calculations showing that at Covehithe the annual loss of land is between 18 and 19 feet! Records of well-sections, and a list of the fossils, are also given in this Memoir.

7. "The Geology of the Carboniferous Limestone, Yoredale Rocks, and Millstone Grit of North Derbyshire." By Prof. A. H. Green, F.R.S., Dr. C. Le Neve Foster, and J. R. Dakyns. Second edition, with additions by Prof. Green and A. Strahan. 8vo. pp. xv. and 212. (London, 1887.) Price 5*s.* 6*d.*

A new edition of this Memoir (which was published originally in 1869) has long been wanted, for the district is one that offers many attractions to the geologist. Some changes are made in the classification of the Millstone Grit and Yoredale Rocks. The portion relating to the Drift has been enlarged, and a small map has been given (p. 97) to show the glaciation of the north-west of England. There is also much additional information about the Caves, Springs, etc., and on the subject of Mining. The list of fossils from the Carboniferous Limestone has been revised, and a Bibliographical List has been appended.

8. "The Geology of the Country around Kendal, Sedbergh, Bowness, and Tebay." By W. Talbot Aveline, and Prof. T. M'K. Hughes. Second edition by A. Strahan. Parts by J. R. Dakyns and R. H. Tiddeman. 8vo. pp. 94. (London, 1888.) Price 2*s.*

The former edition of this Memoir was published in 1871, since then the area has been re-surveyed for Drift. A great deal of new information has been obtained respecting the Volcanic series of Borrowdale, the Coniston Limestone Series, the Stockdale Shales, the Carboniferous rocks, the Shap granite, and the Glacial phenomena. Full lists of fossils are given, and there is also a Table showing the distribution of the Graptolites, by Prof. Lapworth.

II.—Two Works on the late Professor Heer.

1. Oswald Heer: Lebensbild eines Schweizerischen Naturforschers: I. Die Jugendzeit, von Justus Heer; 144 pages, with a Photographic Portrait. II. & III. O. Heer's Forscherarbeit und dessen Persönlichkeit, von C. Schröter, unter Mitwirkung von Gustav Stierlin und Gottfried Heer; 543 pages, 8vo. with a Coloured Plate and many Woodcuts taken from "The Primæval World of Switzerland." (Zurich, P. Schulthess, 1887).

THE great influence exerted by the late Prof. Heer on different branches of Natural History, and especially on the development of palæobotany, has very naturally given rise to the work mentioned above. It contains a sketch of Heer's life and an analysis of his many different works. The author of the first part is Heer's brother, the late Rev. Justus Heer, who gives a very

interesting sketch of the early years of the great palæobotanist. His love for nature began in his early youth, which was passed in the little Alpine village of Matt, of which his father was the clergyman. He first studied the flora and fauna (more especially the insects) of the districts near his home, and subsequently extended his researches to the higher regions of the Alps. He became an intrepid and skilful climber, and the numerous botanical and entomological discoveries made by him in these little accessible regions attracted the notice of many well-known scientific men of his native land. In deference to his father's wish, he had, however, to give up his inclination for scientific pursuits, and betake himself to the University of Halle to prepare for a clerical career. After returning to Switzerland, he declined the offer of a life-long appointment as clergyman, and preferred rather to accept a temporary engagement to arrange and determine the large entomological collections of Escher-Zollikofer; thus definitely undertaking a scientific career.

The second and third parts of the volume are devoted to a critical review of Heer's scientific work, and a sketch of his personal character; the former is more especially interesting since the matters treated are still of the first importance. Dr. Schröter refers first to Heer's work on recent plants, more particularly regarding their geographical distribution, both generally and in the different regions of the Alps. Late in life, Heer again turned his attention to the origin of the Alpine flora, as shown in his posthumous treatise "Die nivale Flora der Schweiz." Equally valuable are his researches on the ancient history of still existing plants, and his paper on the plants of the ancient lake-dwellings (Die Pflanzen der Pfahlbauten) is a genuine classical treatise. Heer's many other botanical works cannot even be mentioned here.

Then comes a chapter, written by Dr. Stierlin, giving a review of Heer's contributions to the knowledge of recent and fossil insects. It is an interesting fact that Heer treated the beetles of Switzerland from precisely the same points of view as the plants; regarding not only their systematic position, but their geographical distribution as well. He was therefore very familiar with the laws of the geographical distribution of plants and animals when he commenced his studies on the ancient floras and insect faunas of the globe. His remarks on the habits and intellectual powers of a species of ant from Madeira (*Œcophthora pusilla*) give great credit to his keen faculty of observation.

Heer's contributions to fossil entomology are indeed astonishing. They will be best understood from the fact that at the time he began his work only about 200 species of fossil insects were known; and he was able from Switzerland alone to describe more than 1000 fossil species, of which 143 were from the Liassic strata of Schambelen, and 876 species from Tertiary beds of other parts of the same country. Besides these, he described a great number of species from the Tertiary deposits of Radoboj and Aix; from the Rhætic beds of Scania, as well as from the Arctic regions, etc. Any one who has read the "Primæval World of Switzerland" will call to mind the

number of ingenious conclusions which Heer has drawn from the presence of these creatures in the rocks—conclusions which could only have been arrived at by one who was thoroughly familiar with the habits of existing forms.

Dr. Schröter devotes several chapters to the most important part of Heer's life-work—namely, his contributions to fossil botany. After passing in review the work done in this branch of science before Heer contributed to it, he proceeds at once to the consideration of the important question as to the reliability of the determinations from dicotyledonous leaves. It has been generally supposed that Heer was himself satisfied as to the validity of determinations thus based; but, as Prof. Schröter points out, this is by no means the case. Heer has thus expressed his views on the point: "In those instances, where the form of the leaves and their nervation are very characteristic, we may, at least with great probability, determine the plant from them; in other cases, its systematic position must be regarded as doubtful until other portions of the plant have been discovered, by means of which the characters drawn from the leaves are corroborated. Leaves of this latter category are of little value from a systematic point of view, but they may, notwithstanding, be of great service in the determination of the geological horizon in which they occur. The systematic position of *Myrica dryandrafolia*, Brongniart, was thus for a long time doubtful. Brongniart himself referred the leaves to *Comptonia*, Ettingshausen to *Dryandra*, whilst Saporta was able at last to show that Brongniart's opinion was correct. But although it was for a long time doubtful whether the leaves belonged to *Myricaceæ* or to the *Proteaceæ*, they nevertheless did good service as characteristic fossils."

Dr. Schröter is quite right in stating that it is unfortunate for the credit of phytopalæontology that names must be given even to those leaves of which the systematic position cannot be ascertained. The mischief would, however, to a certain extent, be avoided by the adoption of the method proposed by the reviewer, that no fossil leaf from strata older than the Pliocene should be placed under an existing genus unless its generic relationship is sufficiently proved by other evidence, in addition to that of the leaf itself. When this cannot be shown, the leaf should either be given an independent generic name, such as *Credneria*, *Dewalquea*, *Protophyllum*, etc., or a name compounded of an existing genus with the suffix *phyllum*. A name of this character would not exclude the idea that the leaf in question might belong to the existing genus, it would only indicate that its congeneric identity had not been proved. If all fossil dicotyledonous genera were revised on this system, we should find that most of the Cretaceous forms would be brought under *Magnoliphyllum*, *Populiphyllum*, *Lauriphyllum*, *Platanophyllum*, etc., instead of *Magnolia*, *Populus*, *Laurus*, and *Platanus*. Of Tertiary plants, a greater percentage would be brought within existing genera, but others would have to retain the provisional suffix *phyllum*. It might even happen that both generic names could be used for different species from the same deposits, as, for example, *Acer arcticum* and

Aceriphyllum inæquale. Then we should know at once that the former species had been proved to belong to the genus *Acer*, whilst the generic position of the latter was still uncertain. In this way the palæobotanist would be able to express the precise degree of our knowledge of a fossil plant.[1]

Dr. Schröter is not an uncritical admirer of everything which Heer has done, but whilst expressing the opinion that Heer had gone too far in determining genera from dicotyledonous leaves, he gently remarks that it has nevertheless been fortunate for science that he had the courage to proceed as far as he did, for otherwise a great number of fossil leaves, which have been rightly determined, and which have proved of the greatest value in furthering our knowledge of the geographical distribution of plants, and of the climates of former epochs, would have been either overlooked or not described. And even supposing that in some cases Heer's determinations of fossil leaves have been insufficiently based, these are more than counterbalanced by the importance of those correctly worked out. According to Dr. Schröter, the total number of new species described by Heer amounts to 1947, and, in addition to these, he has described numerous forms to which names had been already applied by others. These descriptions of fossil plants were accompanied by as many as 704 plates. Heer had indeed the satisfaction to find that the merits of his works were acknowledged by most competent judges, amongst others by Sir Joseph Hooker, who pronounced, as his "candid opinion," that at least two-thirds of Heer's determinations of fossil genera and families were quite correct, and that those correctly determined included nearly everything of importance. Even Lyell was fully convinced of the correctness of Heer's determinations of Tertiary plants.

Under these circumstances it is probable that the attacks made, from time to time, on Heer's methods and results, owe their origin either to imperfect knowledge, or to a misunderstanding of what he has done. Of course, since the time when Heer wrote there have been great advances made in palæobotany, as in every other science, and it is not surprising, therefore, that the methods he followed should now be partly supplanted by better ones. But if we are to condemn every honest worker of a previous age simply because his methods do not agree with our own, who would then escape condemnation? There is no doubt that Heer, in common with every other scientific writer, has made mistakes; but these are so much more than counterbalanced by the excellent work he has done, that it would be decidedly unfair to dwell only on the former, without taking the latter into account.

Much has been written lately on the question whether certain deposits, pronounced by Heer to be of Miocene age, might not, in reality, belong to the Eocene. The question is still undecided; but even if some of these deposits should ultimately prove to be of Eocene age, it must not be forgotten that but little was known of

[1] For further details compare the paper by the reviewer in the "Botanisches Centralblatt," 1886, vol. 25, Ueber die Benennung fossiler Dikotylenblätter.

Eocene floras when Heer wrote, and that the present abundant materials for comparison did not then exist.

Want of space prevents our giving an exhaustive analysis of Dr. Schröter's work. Besides a review of Heer's "Primæval World of Switzerland," so well known to the scientific world of England, and an exhaustive criticism of the "Flora fossilis arctica" (seven vols. 4to. 398 plates, 1868–83), it treats of Heer's contributions to several scientific problems. We may here call to mind that Heer was the first palæobotanist who expressed the opinion that the polar regions had been the centre of distribution for a multitude of plants, especially since Cretaceous and Tertiary times, and this view was developed and defended in many of his works. It is therefore very annoying, Dr. Schröter says, to find a statement in "Nature,"[1] in which Heer is specifically excluded from the list of naturalists who are said to have rendered services to the theory of the migration of plants from the polar regions.

Dr. Schröter gives, further, an exposition of Heer's contributions to the Climatology of ancient epochs; of his phylogenetical studies of different genera and families, and of his position towards the theory of evolution. Heer has generally been regarded as an antagonist to this theory, but this is so far from correct, that he should rather be considered as one of the precursors of Darwin. Already, in 1855, Heer pronounced the opinion that species owed their origin to other species, and he may therefore be looked upon as an evolutionist (compare also Life of Lyell, part ii. p. 246), even though he did not believe in the *gradual* development of species, but considered that the transitional changes were *sudden*, and occurred during certain *short* periods.

The great productivity of Heer as a scientific author, and the diversity of subjects he treated, make it very difficult to obtain a full comprehensive view of his scientific achievements. Next to consulting his original works, the present volume affords us the best idea of the entire life-work of the great palæobotanist of Zurich. No doubt Dr. Schröter's task has been a very difficult one, and there is therefore the more reason to congratulate him on having accomplished it in such a successful manner. A. G. Nathorst.

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2. Oswald Heer: Bibliographie et tables iconographiques, par Godefroy Malloizel; précédé d'une notice biographique par R. Zeiller; avec un portrait d'Oswald Heer. 8vo. pp 176. (Stockholm, F. & G. Beijer, 1888.)

THE volume now under consideration may be said to complete and supplement that by Dr. Schröter, noticed above. Whilst this latter gives a sketch of Heer's life, and a general analysis of his scientific works, the present volume is intended to facilitate references to the works themselves. The biographical sketch by M. Zeiller is limited to ten pages; the rest of the volume by M. Malloizel, Sub-Librarian of the Museum of Natural History, Paris, contains a com-

[1] May, 1879, p. 12.

plete list of the various works, articles and notes published by Heer, arranged according to their dates of publication, which extend from 1832 to 1884. This list comprises from 270 to 280 titles, and it is followed by lists of the fossil animals (except the insects) in "Die Urwelt der Schweiz"; of the insects figured in Heer's various works, and of all the fossil plants described and figured by Heer. As the references include the page, plate, and number of figure for each species, it is evident that the work will prove of immense service to palæobotanists and others desirous of consulting Heer's works. I can state from my own experience that it has already been of much service to me, and a great saving of time and trouble, and M. Malloizel deserves the thanks of all palæobotanists for undertaking the tedious task of preparing this compilation.

A. G. Nathorst.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—April 25, 1888.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "Report on the Recent Work of the Geological Survey in the North-west Highlands of Scotland, based on the field-notes and maps of Messrs. Peach, Horne, Gunn, Clough, Hinxman, and Cadell." Communicated by A. Geikie, LL.D., F.R.S., F.G.S., Director-General.

At the outset a review was given of the researches of other observers, in so far as they forestalled the conclusions to which the Geological Survey had been led. Reference was made to the observations of Macculloch, Hay Cunningham, C. W. Peach, and Salter; to the prolonged controversy between Sir Roderick Murchison and Professor Nicol; to the contributions of Hicks, Bonney, Hudleston, Callaway, Lapworth, Teall, and others. It was shown that Nicol was undoubtedly right in maintaining that there was no conformable sequence from the fossiliferous quartzites and limestones into the eastern schists. It was also pointed out that the conclusions of Professor Lapworth regarding the nature and origin of the eastern schists involve an important departure from Nicol's position, and are practically identical with those obtained independently by the Geological Survey.

The results of the recent survey work among the Archæan rocks may be thus summarized:—(1) the eruption of a series of igneous rocks of a basic type in which pegmatites were formed; (2) the development of rude foliation in these masses, probably by mechanical movement, and their arrangement in gentle anticlines and synclines, the axes of which generally run N.E. and S.W.; (3) the injection of igneous materials, mainly in the form of dykes, into the original gneisses, composed of (*a*) basalt rocks, (*b*) peridotites and palæopicrites, (*c*) microcline-mica rocks, (*d*) granites; (4) the occurrence of mechanical movements giving rise to disruption-lines trending N.W. and S.E., E. and W., N.E. and S.W.; (5) the effects of these movements on the dykes were to change the basalt-rocks into diorites

and hornblende-schists, the peridotites and palæopicrites into talcose schists, the microcline-mica rocks into mica-schists, and the granites into granitoid gneiss; (6) the effects on the gneiss resulted in the formation of sharp folds trending generally N.W. and S.E., the partial or complete reconstruction of the original gneiss along the old foliation-planes, and finally the development of newer schistosity more or less parallel with the prominent disruption-lines.

There is an overwhelming amount of evidence to prove that all these various changes had been superinduced in the Archæan rocks in Pre-Cambrian time.

After reviewing the facts bearing on the denudation of the Archæan land-surface, the order of succession and thickness of the Cambrian strata were given, from which it is apparent that the deposits gradually increase in thickness as we pass southwards from Durness to Loch Broom.

Prior to the deposition of the Silurian sediments the Cambrian strata were folded and extensively denuded. By these means various Cambrian outliers were formed far to the east of the present limits of the formation.

The order of succession of the Silurian strata along the line of complicated structure from Eriboll to Ullapool was described, reference being made to the further subdivision of the "Pipe-rock" and the Ghrudaidh Limestones (Group I. of Durness section). None of the richly fossiliferous zones of Durness is met with along this line, as they occupy higher horizons. An examination of the fossils recently obtained by the Geological Survey from the Durness Limestones confirms Salter's conclusions that they are distinctly of an American type, the Sutherland quartzites and limestones being represented by the Potsdam Sandstones and Calciferous Sand Group of North America.

After the deposition of the limestones, the Cambrian and Silurian strata were pierced by igneous rocks, mainly in the form of sheets, producing important alterations in the sedimentary deposits by contact-metamorphism, the quartzites becoming crystalline, and the limestones being converted into marble.

When this outburst of volcanic activity had ceased, terrestrial displacements ensued on a stupendous scale. By means of powerful thrusts the Silurian strata were piled on each other, and huge slices of the old Archæan platform, with the Cambrian and Silurian strata resting on it, were driven westwards for miles. With the view of illustrating the extraordinary complications produced by these movements, a series of horizontal sections was described drawn across the line between Eriboll and Ullapool.

The evidence relating to regional metamorphism was next referred to, from which it is obvious that with each successive maximum thrust there is a progressive amount of alteration in the displaced masses, as the observer passes eastwards to the higher thrust-planes. Eventually the Archæan gneiss is so deformed that the Pre-Cambrian foliation disappears and is replaced by new divisional planes; the Cambrian grits and shales are converted into schists; the Silurian

quartzites into quartz-schists; the limestones become crystalline; the sheets of intrusive felsite, diorite, and granitoid rock pass into sericite schist, hornblende-schist, and augen-gneiss respectively.

The researches furnish a vast amount of evidence in support of the theory that regional metamorphism is due to the dynamical and chemical effects of mechanical movement acting on crystalline and clastic rocks. It is also clear that regional metamorphism need not be confined to any particular geological period, because in the N.W. Highlands, both in Pre-Cambrian time and after the deposition of the Durness Limestone (Lower Silurian), crystalline schists and gneiss were produced on a magnificent scale.

2. "On the Horizontal Movements of Rocks, and the Relation of these Movements to the Formation of Dykes and Faults and to Denudation and the Thickening of Strata." By William Barlow, Esq., F.G.S.

The paper commenced with a description of some horizontal movements of rocks caused by gravitation; and the author quoted Mr. C. E. Dutton's descriptions of the Grand Cañon District, especially noting the fact that between succeeding escarpments the strata dip slightly from the crest of the one below to the foot of the next above, and that whilst the strata of the median parts of each terrace are nearly horizontal, the inclination increases as we approach the escarpment of the next higher terrace, and also that Dutton observed indications of a slight elevation of the unloaded strata within the denuded elliptical area known as the "San Rafael Swell." After alluding to Dutton's suggestion that the phenomenon referred to is analogous to the action of creeping in deep mines, the author discussed the nature of such "creeps," which he defined as the thickening of the parts of beds from which a load of superincumbent rock has been lifted, caused by a thinning of the adjoining parts which remained loaded, some of the substance of the latter having been squeezed out to furnish the material for the thickening, and suggested that some of the subsidiary plications found on the flanks of mountains are caused by the thrusts arising from creeps. He also paralleled the fissures in the precipices of the Grand Cañon District with those produced in the pillars of coal owing to the strain induced by the slight inequality in the yielding of the bed supporting it, and pointed out how such fissures would facilitate denudation, giving instances recorded by Dutton, and that an appreciable influence might be thus produced in all cases of mountain-denudation.

The author next considered the case of a body of molten rock below a considerable mass of solid rock. The pressure upon the molten mass would cause movement to take place towards the point where the superincumbent weight was least, provided that absolute equilibrium did not exist. The overlying rocks being more or less plastic, some horizontal movement of the solid rocks at the confines of the molten mass, and subjected to its influence, might be looked for. Any such yielding would tend to draw apart the solid crust resting upon the molten rock, and the ground would open along lines of weakness, such as would be produced by the presence of joints, the crust in some cases breaking up into larger or smaller fragments.

When a large mass of molten matter occurred near the surface, and a fissure was produced in the way described, the weight of the ruptured crust would, if the plastic mass beneath were sufficiently liquid, cause the latter to rise in the fissure, producing dykes. Attention was called to the fact observed by Dutton that basaltic vents frequently occur on the brink of cliffs, but never at their bases; also to the existence of dykes having a strike parallel to the Colorado River. In most cases the vertical fissures which received the molten rock would begin to open from below, and the upper strata might altogether escape rupture.

The author discussed the case of the Henry Mountains, and explained the formation of flat-topped and flat-bottomed dykes according to his views. He next called attention to the influence which the motions of the rocks had exercised in determining directions of drainage when fissures left unfilled became occupied by streams. He next alluded to river-valleys, the existence of which had been accounted for by "antecedent" and "superimposed" drainage, and suggested difficulties in the way of accepting the explanations hitherto advanced, and considered them to be instances of fissuring produced by movements of the strata due to the pressure of a mass of molten or highly plastic rock spreading laterally.

After treating of the formation of faults with normal hade, which he referred in some cases to rupture of the solid crust by the spread of a vast mass of viscous matter lying beneath it (the faults being sometimes replaced above by monoclinal folds), he referred in conclusion to the extent of the horizontal compression of the earth's superficial crust, which is seen to be associated with the elevation of mountain-ranges, and called attention to some evidence that the thickening of the strata caused thereby would be more considerable and general than ordinarily supposed.

3. "Notes on a Recent Discovery of *Stigmaria ficoides* at Clayton, Yorkshire." By Samuel A. Adamson, Esq., F.G.S.

The specimen described was obtained in November, 1887, from the beds between the Better-bed Coal and the Elland Flagstone of the Fall-top Quarries of Messrs. Murgatroyd. The author gave measurements of the specimen, and compared them with those of another found in the same quarry in 1886, and now preserved in the Owens College, and with those of a third obtained in an adjoining quarry.

CORRESPONDENCE.

ROUNDING OF PEBBLES BY ALPINE RIVERS.

Sir,—Mr. Irving's remarks in your last number appear to call for a few words in reply. As my paper was entitled "On the Rounding of Pebbles by Alpine Rivers," I fail to see that I was bound to discuss other modes of forming pebbles, unless they seriously interfered with the inductions which I was attempting to draw. Hence, I did not mention "the weathering of débris on the mountain sides," because, so far as that had a bearing on my subject,

it strengthened my argument, which was to show that a respectable pebble was not easily made by running water, and because, in the case of the rocks with which I was dealing, the rounding mentioned by Mr. Irving is, as a rule, a very secondary and subordinate matter.

(1.) Every one knows that certain rocks become tolerably rounded by mere aërial waste, but the débris which reaches Alpine torrents (in the districts of which I spoke) is commonly angular; and this is equally true of the material to which my inferences applied. I may add that I believe few things are more important in attempting to reason inductively from observed facts than to be careful in preserving a due relation between quantities of the first and second order of magnitude (as they are called by mathematicians). Overmuch precision of statement and an elaborate parade of small details interfere with our sense of proportion, and there is great danger, if you look at a sprat for too long a time, and from too near a point of view, that you may at last fancy it a whale.

(2.) In regard to "the scouring action of sand," I cannot pretend to say how much is done by the knocking of the pebbles together, and how much by the friction of passing sand; but I certainly cannot make the distinction which Mr. Irving attempts to do. All the rivers of which I spoke transport quantities of sand as well as pebbles in all parts of their course, though it is only in the lower part that they can deposit much of the former. However, as it takes a very long journey to remove the angles from a grain of sand, I have my doubts as to its conspicuous efficiency as a fashioner of pebbles out of pieces of hard rock, and if Mr. Irving alludes to the action of sand on pebbles which but rarely travel, then I think it would tend to flatten rather than to round them.

(3.) In regard to the general question raised, viz. the origin of the pebbles and other materials of the Bunter group, space will not permit me to enter into details, so I must forbear to criticize minor but not unimportant points in Mr. Irving's letter, such as "the pebble-beds proper being quite *local*," a statement which is only true if a most liberally extended sense be given to the last word. But I express a fundamental dissent by asking whether there is any evidence at all in favour of the Bunter being a marine deposit, and still more a deposit in a sea where, according to the ordinary rules, strong coast currents or a rolling surf would be likely to exist. All I can say is that the Bunter as a whole is remarkably unlike every admitted marine formation which I have ever examined, while it presents a strong resemblance to such deposits as parts of the Old Red Sandstone, some beds in the Lower Carboniferous of Scotland, and the Nagelflue of the Alps: deposits, which most geologists agree in considering more or less fluviatile: nay, allowing for a slight difference in colour and hardness, the Bunter pebble-beds of Central England (I said nothing about Southern England) are indistinguishable from many of the old sub-Alpine river-drifts which I have repeatedly examined.

T. G. Bonney.

GRAPHITE AT KENDAL.

Sir,—A few days ago, in digging a grave in the cemetery at Kendal, a piece of graphite weighing about five ounces was found in the Glacial Drift of which the ground is composed. The cemetery is at the southern base of the Castle Hill, a large drumlin containing boulders and gravel, of Shap granite, Kirkby Moor flags (Ludlow), Ash (Borrowdale series), and other rocks. The granite is only found on the northern half of the hill. The other rocks might be derived from the valleys which converge on Kendal or in the line of boulder flow from Shap.

Unfortunately the graphite was not found in undisturbed drift. It lay a short distance above the lid of the coffin of an earlier interment made about 17 years ago. But it was so coated with soil that if it had not been accidentally scratched with the spade in digging, the sexton would not have noticed anything peculiar about it, and it is very probable that it may have been thrown out when the original grave was made, and reburied when the grave was filled in.

That it was brought by other than nature's agency is not likely. It was not usual at the date of the earlier interment to place ornaments on the graves, and the piece of graphite is not an article likely to be used for that purpose.

Probably therefore it has been brought down with the drift from some deposit of graphite to the North or North-East. It is not likely to have come from Borrowdale; for I know of no instance of the discovery of any rock which can be distinctly traced to that region in the Kendal drift.

Graphite being rare and destructible, I thought it might be of interest to record the discovery.

Geo. Crewdson.

St. George's Vicarage, Kendal,
9th May, 1888.

THE METAMORPHIC ROCKS OF SOUTH DEVON.

Sir,—In reply to Miss C. A. Raisin's letter (see Geol. Mag. p. 190) the chloritic rock is a little on the north (or more correctly the north-west) side of Prof. Bonney's fault-line where first indicated at the commencement of his "true schists." These schists are also in their line of strike, on the south side of the chloritic rock. A recent visit has, however, enabled me to find these chloritic rocks still further north, across the stream on the north flank of the valley, so that the stream cannot be regarded as marking a line of fault, which from physical appearances it might seem to do.

59, Fleet Street, Torquay. Alex. Somervail.

OBITUARY.

WALTER KEEPING, M.A.,

born January 6, 1854; died February 22, 1888.

Mr. Walter Keeping has for six years been lost to his friends and to science. In the vigour of early manhood he was somewhat

suddenly struck down by a form of paralysis, well known to medical men, which seldom spares its victim so long as in the present case. Previous to those six years we see him in full intellectual activity, after a distinguished University career and a period of further training as a teacher himself, settled down in charge of the magnificent collections in the York Museum, and giving promise of much valuable work for science.

His early education was carried on alongside of work, which he had to perform in positions of more or less importance and trust, ending in the post of assistant to his father in the Woodwardian Museum. At the age of 19 he won a Scholarship at Christ's College, and in due course graduated, obtaining a distinguished position in the First Class of the Natural Sciences Tripos of 1877. He continued to work in the Woodwardian Museum until he was appointed Professor of Natural Science in the University College of Wales at Aberystwith. His quickness of observation always attracted him to the study of the Geology of the district in which he resided.

The Lower Greensand of the neighbourhood of Cambridge, with its derivative fossils and rocks, as well as those which belonged to the age of the deposit, had received great importance from the economic value of the phosphatic nodules it contained, and early engaged his attention. It was then beginning to be the fashion to speak of it as Neocomian. In 1875 he published a paper in the Geological Magazine on "The Occurrence of Neocomian Sands with Phosphatic Nodules at Brickhill." Five years later he contributed a paper to this Magazine on "The Included Pebbles of the Upper Neocomian Sands of the South East of England, especially those of the Upware and Potton Pebble-beds"; and in 1883 the Sedgwick Prize was awarded him for his Essay upon "The Fossils and Palæontological Affinities of the Neocomian Deposits of Upware and Brickhill."

He was especially interested in the Echinodermata, and in 1876 and 1878 contributed some valuable Palæontological Notes to the Journal of the Geological Society in his papers on Palæozoic Echini; on the Discovery of *Melonites* in Britain; and on *Pelanechinus*, a new genus of sea-urchins from the Coral Rag.

On his appointment to the Chair of Natural Science at Aberystwith, he turned his attention to the geology of the surrounding district, which he described in this Magazine in 1878, and in a paper on "The Geology of Central Wales," read before the Geological Society in 1881.

These and various other notes and papers, recording observations made by him in the British Isles and on the Continent, show a keen perception of details and a power of generalization, which led his friends to anticipate for him a long career of distinction and useful work. But soon after his appointment to the Curatorship of the York Museum, his health broke down, and after six years painful illness, he passed away in February, 1888.

Thos. McKenny Hughes.